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THE RELATION OF ENGINEERING TO EVERYTHING.

THE lecture of Dr. John Hopkinson at the Institution of Civil Engineers was intended, apparently, to exhibit the scope of mathematical knowledge throughout the various branches of engineering. Instances of the application of the calculus to problems involving the strength and rigidity of materials through the wide range of machine design, were given in the case of shafting, girders, and struts; and its domain was further extended to the more complex questions concerned in the transmission of electrical impulses through long cables, examples which were delicately touched upon by the lecturer, and as lightly let go. The practical applications of thermo-dynamics to engineering were also brought to the front, and the mutual bearing between the two sciences was viewed all round; everything, in fact, from the mariner's compass to the mariner's lighthouse was put in evidence, and yet the lecture presented nothing strikingly novel or usefully suggestive.

"The Relation of Mathematics to Engineering" is a title a little ill chosen, being practically a revised version of the text from which Dr. Anderson preached the "James Forrest" sermon last year. We sincerely hope that the next lecturer will discourse upon "The interdependence of, and relation between, Abstract Science, Mathematics, Engineering, and *everything*," and so clear the way once and for all to some thing more appropriate to the work of the Institution. These topics are well enough in their place, but engineers cannot afford more than one evening a lifetime to their consideration. The "James Forrest" lectures present an occasion when really serious work could be, and ought to be, discussed.

Otherwise, we think, Dr. Hopkinson did excellent service in trying to instil a little enthusiasm into the hearts of engineers by giving them an insight into the beauty and delight as well as the strength and commercial worth of mathematics. Fortunately the day is past for those who would taboo mathematics as a senseless abstraction, for everyone knows that there are problems ahead, at any rate for electricians, with which only mathematicians will be able to cope; and only those men will succeed in their profession who have grasped sufficient mathematics to enable them to meet the cases as they come.

The lecturer gave some needed advice when he said: "We cannot get more out of the mathematical mill than we put into it, though we may get it into a form infinitely more useful for our purpose." We venture to put by the side of this an eloquent sentence from Huxley, who observed that "Mathematics may be compared to a mill, of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and, as the grandest mill in the world will not ex-

tract wheat-flour from peascods, so pages of formulæ will not get a definite result from loose data."

Mathematics should be regarded as a kind of mental shorthand; a ready means for stating a proposition exactly; an instrument for recording thoughts so that they cannot be misconstrued. It is no longer to be associated with things uninteresting and vague; the reverse is undoubtedly the fact; to a mathematician, there is as much delight in the solution of a problem as a musician finds in composing a sonata. Mathematics is not essential to the art of theorising, but it is essential to the art of theorising rightly; it is the only economical method of thought. It was Darwin's belief that "no one could be a good observer unless he was an active theoriser." Then, too, a mathematician can generally give points to a logician in a subtle argument, for it implies no trickery stronger than the truth.

Rubber to the Fore Again.

THE belief in the reliability of India-rubber for submarine cable cores in tropical climates manifested by the Cuba Submarine Telegraph Company is based on a long experience, and the satisfactory state of the balance-sheets of the last few years has amply proved the soundness of their faith. In this respect it is interesting to turn to the report of the meeting of the Cuba Company held in February last, at which the chairman mentioned that a cable of 400 miles, laid in 1870, had been abandoned, and a further section of 200 miles would probably have to be abandoned. It is of great significance that cables laid in 1875, 1881, and 1891, which the chairman said were in good working condition, are of India-rubber. He would have been a bold man, who 12 years ago would have specified for rubber core on Hooper's principle for a long line of cable, but apparently this state of things is changing, for as we note elsewhere, Hooper's Telegraph and India Rubber Works, Limited, have secured a contract from the Cuba Submarine Company for a line of cable in the West Indies, the specification for this cable being that it should be insulated on Hooper's principle. There is no necessity to dwell upon the departure from general practice which this specification involves. The Cuba Company have had experience of both classes of cables, with the result that justice—somewhat tardily it must be admitted—has been done to rubber. As a matter of fact, we see no reason why India-rubber should not be depended upon equally with gutta-percha as an efficient insulator, and we sincerely trust that success may attend the new cable, thereby still further justifying the Cuba Company in their belief.

Metallic Electrolysis in Therapeutics.

TREATMENT by metallic electrolysis is developing, and its wide sphere of usefulness is becoming daily more apparent. In a paper by Dr. Margaret Cleaves, recently published in the *Journal of the American Medical Association*, this is strongly evidenced, and the details given of numerous cases, and the special adaptation of the method to each case, are both instructive and interesting. The author states that what she means by metallic electrolysis is "a method which makes use of the chemic action of the positive pole, both upon foreign substances—that is, metals such as copper, zinc, and iron—and the tissues at the same time." Dr. W. E. Steavenson is quoted as having, to some extent, foreshadowed this method in the words: "If the electrode is made of zinc, chloride of zinc is formed, which exerts its own specific action on the tissues, in addition to the oxidising effect of the liberated oxygen." The researches of Gautier are next epitomised, and various experiments, most of which have already been published in the ELECTRICAL REVIEW, are mentioned. The value of the paper rests, however, mainly upon the record it contains of practical experience of metallic electrolysis in the Electro-Therapeutic Clinic of the Post Graduate Medical School of New York, under Dr. Wm. J. Morton, assisted by the author. "It has been used in hypertrophic rhinitis, ozena, chronic coryza, nasal polypi, sebaceous cysts, chronic urethritis, hemorrhoids, anal fissure, epithelioma, cancroid, and chronic conjunctivitis. An experience of twenty months is given, and we quote the following case as illustrative of the method and its success: F. D., aged 8, with double trachoma, was brought from an institution where there were 24 boys, 'all with sore eyes.' He had purulent conjunctivitis with congestion and edema of the surrounding tissues, and the lower lids were covered with enlarged conjunctival papillæ, the upper showing the frog spawn granulations very markedly. Treatment was begun July 21st, 1893. Five applications of cupric electrolysis were made in this case by means of an oval copper electrode, insulated on one face to prevent its coming in contact with the edge of the lid, as there is danger of this when the pain becomes severe and the lids gradually contract and retract. A C.S. of from 3 to 7 milliampères was used from 3 to 5 minutes. A solution of cocaine was dropped in the eye prior to the application. The treatments were given at intervals of 3, 12, 11, and 9 days. After the first treatment less soreness, lachrymation, and photophobia were present, and the trachomatous bodies were much softer. Recovered."

Relative Engine and Dynamo Capacities.

MR. O. T. CROSBY, who has achieved considerable repute in electric traction subjects, contributes a short article in *Cassier's Magazine* on the proper proportions of a dynamo and its engine. He states that the running of a dynamo below its best capacity is by no means so wasteful a process as the same treatment of an engine. Very usually and properly a dynamo is kept below its maximum, from which it follows that if the engine be of 600 H.P. for a dynamo of only 500 H.P., this must have the effect of very seriously underloading the engine. If, however, the engine be of the same rated capacity as the dynamo, the easy running of the latter will simply allow easy working of the former without too great a drop below the efficient and economical normal rate of work. Mr. Crosby gathers from various engineers that there is quite a consensus of opinion in favour, if anything, of having an engine of slightly less rated capacity than the dynamo. It is thereby secured that the engine will require to work more nearly to its economical rating for the maximum period. As regards the relative advantages of horizontal and vertical engines, the opinion is expressed that the choice between these types is one rather of land values than anything else. And, as to the use of condensation, the dictum of a competent engineer is quoted to the effect that where coal costs about 12s. a ton it will pay to lay out £20 per horse-power in condensing apparatus. Surely there is some error in this. To lay out £20,000 on a 1,000 H.P. engine to secure the saving due to condensation would cost £1,000 a year on interest account only. Probably the sum named, 100 dollars, is a misprint for 1 or for 10 dollars. Nominally, it would pay to lay out 10 dollars, but this implies more than the conversion would as a rule cost, unless special works were necessary to bring water or construct dams to retain it. Condensation is too much neglected, and by none more than London managers. Indeed, the use of appliances as to which there are no doubts in respect to their securing the economy claimed for them, appears to vary in inverse ratio to the cost of coal. Feed-water heaters are, for example, more frequently met with, and of larger ratio to the power, upon the coalfields of the north of England than among the steam users of London and the south generally.

OIL FUEL AT THE WORLD'S FAIR.

As is well known, all the steam boilers at the Chicago Exhibition were fired with oil, and in an American contemporary, *Electrical Engineering*, a concise review of the leading features of the arrangements adopted was, a few weeks ago, given by Mr. C. V. Billow. It appears that a total of 32,315,964 horse-power hours were developed by the steam plant, as shown by the official records. The cost of this is given as 6·3 mils per standard horse-power hour, of which 5·7 mils covers the cost of the oil and 0·6 mil covers the cost of handling and all salaries. A mil is the thousandth part of a dollar or one-twentieth of a penny. A horse-power hour thus costs less than one-third of a penny. As compared with the cost of steam power in England, we may point out that with coal at 10s. per ton the cost of a thousand horse-power indicated with engines using two pounds of coal per horse-power hour will be less than one-eighth of a penny per ton, including salaries of engineer and fireman. The coal users' point of view is taken up in the same journal by Mr. Hazelton, who shows that the cost of coal-developed power runs as low as ·225 of a penny per horse-power hour with coal ranging from 6s. to 16s. per ton, and he contends that had coal been used at the Fair, where it could have been had for under 8s. 6d. per ton (2,000 lbs.), the economy in money would have been 21 per cent. He cannot, therefore, accept Mr. Billow's contention as to oil being cheaper, though he does not deny the fact that oil was a success, and under the circumstances altogether a better fuel, being clean and smokeless. The oil usually employed for fuel is the residual from the distillation of crude petroleum. Its fire test is 350° F. It is limpid at 100° F., but sluggish at 40° F. As compared with best lump coal as much steam can be raised by 126 gallons of oil as by 2,000 pounds of coal (a United States gallon is only 8¼rd pounds of water). For high temperatures, as in glass making, &c., 84 gallons will do as much as 2,000 lbs. best coal. The oil supplied to the exhibition cost 3s. 0½d. per barrel of 42 gallons, and weighed 7 pounds per gallon. The oil was stored in tanks in a cemented brick vault roofed and sodded over, and was conveyed to these tanks through a 6-inch pipe from a pumping station 22 miles distant, to which a pipe line was brought 300 miles from the Ohio oil fields. The pressure in the tank supply pipe was 400 to 600 pounds, and a fresh supply was sent forward each day, the tank capacity being 112,500 gallons.

From the tank a 6-inch pipe was laid in a wooden channel 12 inches below surface with a rise from the tanks of 1 inch per 500 feet, or 8 inches in all. Near the boiler house a connection was made to an 8-inch pipe, with a vertical loop rising within 2 feet of the normal level of the oil in a 30-inch diameter stand pipe at the tank pumps, which rose 30 feet, the pumps having a capacity of 600 gallons per minute. Thence pipes lead off to the boilers, of which there were 52, with a total of 210 burners, of 7 types, upon 2-inch supply pipes. All the burners were steam worked atomisers, and there was provision made for shutting off the flow of oil near the boiler house, and also electrical signalling, and everything demanded by the insurance offices.

The evaporation is given as 14·25 pounds of water per pound of oil, and Mr. Billow, who takes coal at nearly 13s. per 2,000 pounds and allows it an evaporative efficiency of only 7 pounds, thus finds a saving by use of oil of about 24 per cent. It is all a question of price. Liquid fuel generally appears to be about doubly as efficient as coal in weight of water evaporated. We believe this is about the figure found for the locomotives on the Great Eastern Railway, which burn mixtures of tar, green oil, &c.; but the convenience of liquid fuel is undoubted.

Our contemporary states, editorially, that the atomising of the oil by high pressure steam, calls for from 2 to 7 per cent. of the entire production of the boiler for best results, and considers better results may be secured, as proved by the experience now gained, by utilising direct pressure to circulate the oil, and low pressure steam to convey the flame into the furnace; while feeding the oil at or near its volatilising temperature, ensures speedy vaporisation with a soft and diffusive flame and more economical results. In the Wells light something of this sort is carried out. As compared with the cost of 1,000 horse-power with coal at 10s. per ton, the cost of oil fuel comes out at 0·144 of a penny per horse-power hour against 0·128. This is supposing we could buy oil for 3s. per barrel of 294 pounds. In London, where some people pay regularly 20s. per ton of coal, it would be as cheap to use oil at 5s. per barrel or thereabouts. If anything of the sort is to be done in England, it will not be effected without the carriage of the oil in bulk and its conveyance from the ship in pipe lines as done in America. In a town like Oldham, where steam plants of 1,000 horse-power are thickly scattered over the whole place, some concerted action on the part of the limited companies might secure a pipe line from the Manchester Ship Canal from which all the mills might be supplied.

It would appear that oil to supply at least fifty full sized factories, of 1,000 horse-power, could be passed through a 6 inch main very comfortably, and if coal in England is to go on increasing in price, it would be well to turn attention to the oil supply of Burmah and Baku, and consider the better transport of this fuel in bulk. It should be perfectly safe ashore if properly stored in sunk tanks.

Where working is continuous, oil is easy to regulate, and the smokeless combustion is so simple to secure, that the general use of liquid fuel would at once settle the question of the smoke nuisance so far as factories are concerned. The general use of oil for steam production would deprive the gas engine of some of its present advantages, for an oil fire can at once be stopped when done with, and all further expense saved.

ELECTRICALLY TIMING RACES.

In timing foot and other races with stop watches, errors are liable to occur, and for this reason three persons are usually employed to take the time and act as checks upon each other. Even with practised timekeepers it is not unusual for the times of all three to differ, showing that the time of a race taken in this way cannot be relied upon as being absolutely exact.

At present the difference of a fifth of a second in the time of a race is of the utmost importance, as it may mean the breaking of a world's record. Out of justice, therefore, to the competitors, if for no other reason, an accurate and reliable system of timing should be employed.

Such a method has been devised by Prof. C. H. McLeod, of McGill University, Montreal, Canada, and has been used with great success since 1883 by the Montreal Amateur Athletic Association. It is based upon the chronographic method used for timing astronomical events where extreme accuracy is required. This method requires a chronograph, a timepiece provided with a circuit interrupter, and an electric circuit adjacent to the race track.

A fairly good clock will answer for the timepiece, preferably one having a seconds pendulum. The circuit interrupter is operated by the pendulum or movement of the clock, so as to interrupt the circuit each second. The chronograph may be a very simple instrument, as is the case at Montreal, where its barrel is controlled by a train and air fan. Over the barrel is a stylographic pen attached to the armature of an electro-magnet, which is mounted upon a rod provided with a screw thread. The rod is parallel to the barrel, and is turned by the clock movement which rotates the barrel. The pen is thus propelled along the rotating barrel, and traces a spiral line upon a sheet of paper wound around the barrel. The electro-magnet is in circuit with a battery of gravity cells and the circuit interrupter on the clock. Each second when the circuit is interrupted the armature is drawn away from the magnet by a retractile spring, and the pen makes a V-shaped deviation from the spiral line.

The wires of the circuit extend along the track, and plug cut-out switches are located in the circuit opposite the starting and finishing points of the races. The starting pistol is provided with a circuit breaker, consisting essentially of two springs whose ends are in contact in front of the muzzle of the pistol. The springs are connected to a plug by flexible conductors, and are included in the circuit by inserting the plug in the switch opposite the starting point. When the pistol is fired to start a race the gases ejected from its mouth separate the springs for a moment and interrupt the circuit, causing a deviation mark to be made on the chronograph record.

At the finishing line a stout thread is stretched tightly across the track at a suitable height between two poles. The spring and contact are included in the circuit by flexible conductors attached to a plug, which is inserted in the opposite switch. The first man, or racer, to reach the finish, pushes the thread aside and pulls the spring away from the contact, thus opening the circuit and making a record on the chronograph. A deflection of the thread of an inch or two is sufficient to open the circuit, and, as soon as the tension is great enough, the thread breaks, allowing the runner to pass and the spring to return to the contact.

The paper is removed from the chronograph barrel, and the time of the race is ascertained by counting the seconds marks of the clock between the starting and finishing marks on the record, measuring the fractional distances between the first and last of the seconds marks and the starting and finishing marks respectively, and adding all together. In this way, the time may be accurately calculated down to one-twentieth of a second, and even lower, if desired; whereas, with a stop watch, the smallest fraction of time that can be measured is a fifth of a second.

THE INCANDESCENCE LAMP.*

By A. BAINVILLE.

The employment of the incandescence lamp is growing more general every day. After having invaded the factory, the workshop, the office, shops, and public buildings, it has at last penetrated into the domain of private life.

From the drawing-room, where it served at first to contribute to the brilliancy of our entertainments, it soon spread all over the house.

Its success may be attributed to the fact that it lends itself admirably to the various purposes for which it is employed. Its light may be made either soft or brilliant without ever having the glare of the arc. It can, moreover, be placed in any position. Its use produces the most charming effects, and has evolved a new phase of æstheticism. Thus it is useful not only for illumination but also for decoration.

But besides this, the incandescence lamp is the transformer to which we owe the extensive development of electrical industry. From the time of its appearance dates the creation of most of our electrical installations. Electricians, therefore, as well as consumers, owe it a debt of gratitude.

As up to the present its manufacture has been shrouded in mystery, and as even now it is a matter of considerable difficulty to effect an entrance into a lamp factory, this little article, precious from so many points of view, is very imperfectly understood.

We know very well what an amount of labour a lamp represents, what scrupulous attention must be given to every little detail of its manufacture, and what great difficulties have had to be surmounted to arrive at the result that we have now attained, although that is far from perfection. The art of making incandescence lamps, besides the points we have just mentioned, lies chiefly in certain details and certain modes of procedure which are only well known to those engaged in this manufacture. It is not essential that we should know all these trade secrets, but we thought it might be interesting to describe the outlines of the processes employed in this manufacture.

In this article, then, we propose to describe briefly the methods in use and the apparatus employed for the production of a lamp. We shall incidentally indicate the practical conditions under which the lamps should be used, the limits of their regular working, and the various causes of depreciation; we shall also examine the new forms that have been proposed, such as lamps with many filaments, lamps with sealed globes, &c., and lastly, we shall discuss the series of experiments recently published. We will begin with a brief sketch of the history, and an explanation of the theory of the incandescence lamp. The incandescence lamp, in its present form, dates from 1880 only. It was Edison who, acting on the ideas conceived up to that time, gave it a practical form, and at the same time brought its manufacture into the domains of industry. I shall only briefly remind our readers of the lamps with the spiral of platinum, which contained within themselves the causes of their destruction. Edison tried this metal filament before using carbon, which had also been suggested before his time. The lamps that we produce now only differ from the Edison lamp of 1880 in that they are better understood and more carefully made. This is the logical consequence of the progress necessarily realised by a new industry which extends rapidly.

The improvements all bear upon points in the manufacture. We will discuss the principal. The filament of the Edison lamp was not homogeneous; neither those made from the carbonisation of paper or cardboard, nor those he made afterwards, beginning with bamboo. It was Swan who was the first to obtain a really homogeneous filament by using parchmentised cotton. Since then various substances have been employed, but without arriving at much better results. The use of vegetable fibres and silk has been almost entirely abandoned.

Great improvements have also been made in the mode of obtaining the vacuum, especially in England; although here, again, we have only followed in the path indicated by Edison. By modifying the form of the pumps, we have succeeded in obtaining more perfect vacuums in a shorter time, but, as far as we know, no good mechanical pneumatic pump, doing away with the employment of mercury, has been arrived at as yet. This result is not very likely to be attained, and, even if it were, we should not get a more perfect vacuum; the only advantage gained would be to shorten the time taken up by the operation, and consequently to lessen the cost of manufacture. The mode of conveying the current to the lamp has also undergone some modifications. The Edison holder and socket are, however, still in use. The bayonet style of fitting, which seems to be in favour just now, has only the advantage of simplicity over the Edison style. Several other forms of mounting — serving, so to speak, as trade marks—have been sent out by various makers; but these forms, which do not constitute any marked improvement, are gradually disappearing. The manufacture of the bulbs has also progressed, and the blown globes which were used at first, and the form of which was not rigorously defined, has been succeeded by the moulded bulb, which leaves nothing to be desired as regards regularity.

We must also mention the progress realised in the carbonisation of the filaments and in the soldering of the filament to its metallic support; the carburetting or flashing of the filaments has also been effected.

Thanks to all these improvements, which we will discuss in turn, we have at length succeeded in turning out in an unvarying manner any given type of lamp.

The incandescence lamp consists essentially of a conductor which is heated until it becomes luminous by the passage of a current. This conductor is fixed in a transparent enclosure in which as perfect a vacuum as possible has been made. The object of this vacuum is to prevent the oxidation of the conductor, and at the same time it considerably reduces losses of heat by convection. The conductor can be introduced into an electrical circuit by its extremities which emerge from the enclosure; it then consists of two parts of unequal conductivity; the part which is outside the enclosure should not, under any circumstances, become luminous, or even be appreciably heated.

The conductor of the least conductivity is the filament of the lamp; the other, which we will call the leading-in wires, consists of the two metallic wires which pass into the enclosure or bulb. The extremities of these wires, which are outside the bulb, are connected to a special part called the holder which protects them and enables the lamp to be readily introduced into a circuit in which the counterpart of this holder has already been fixed, viz., the socket. To render the filament of an incandescence lamp luminous, we must supply it with a certain quantity of energy.

This expenditure of energy during the time, t, is represented by Joule's law,

$$Q = r i^2 t, \qquad (1)$$

in which r represents the resistance of the filament, and i the intensity of the current passing through it. It may also be expressed by the quantity of heat which must be supplied to the filament to keep it at the temperature, θ, and which may be represented by the equation,

$$Q = m \theta, \qquad (2)$$

* *L'Electricien.*

m being a coefficient varying according to the material of which the filament is composed.

This expenditure of energy corresponds to a certain quantity of light emitted by the filament and in proportion, all other conditions being equal, to the sum of the total radiations, L, given for the unit of time by Stéphan's law:

$$L = S E T^4, \qquad (3)$$

in which S is the surface of the filament;
E, its total absolute emissive power;
T, its absolute temperature.

The comparison of equations (2) and (3) shows us that the quantity of energy to be expended in order to produce a given sum of radiations diminishes rapidly in proportion as the temperature rises.

As the proportion between the luminous radiations and the total radiations itself increases with the temperature, the consumption of energy corresponding to the production of a given luminous power will be *a fortiori* greatly reduced if we raise the temperature of the filaments. Nevertheless, with incandescent carbon, this proportion is not higher than 5 per cent. under the best possible conditions, *i.e.*, for the highest temperature that the filament can attain.

In practice, an incandescent lamp is characterised by the difference of potential, e, that must be established at its terminals in order that the current passing through the filament may be equal to i; *i.e.*, in order that this filament may be brought to such a temperature that it is capable of supplying a quantity of light, b, expressed in decimal candles. Thus the quotient $\frac{e\,i}{b}$ of the watts expended per second by the luminous power in decimal candles determines the temperature to which the filament is brought. This is the *régime* of working of the lamp, or its consumption per decimal candle. We must observe, however, that this *régime* of working does not characterise the brilliancy of the filament. In fact, the relation between the consumption of energy per luminous unit and the temperature depends on the specific resistance and the emissive power of the filament. This relation is, on the other hand, quite independent of its shape and length; in other words, for filaments having the same specific resistance and the same emissive power, the radiating surface will be the same per luminous unit for a given *régime*, whatever may be the section of the filaments. As the temperature and, consequently, the luminous intensity for a given filament are in proportion to the intensity of the current, it follows that an incandescence lamp will have a wide range of working, the variation of temperature being comprised between red heat and the fusion of the carbon. We are not now taking into consideration secondary causes, which we shall discuss later, and which confine the working of the lamps within narrower limits. We shall also have to determine what are, in each particular case, the best conditions of working.

We will now indicate the relations that connect the dimensions of the filaments with the luminous power, and the consumption of electrical energy that we wish to obtain. The following formulæ will enable us to calculate for any type of lamp whatever. We will suppose, for the sake of simplicity, that the filaments have a circular section, as is usually the case. Let

l be the length of the filament;
d, its diameter;
r, its resistance;
ρ, its specific resistance;
i, the intensity of the current passing through it;
e, the difference of potential at the terminals;
b, the luminous power in decimal candles;
η, the consumption in watts per decimal candle.

The intensity of the current is determined by the relation

$$i = \frac{\eta\, b}{e}$$

We will now find the section of the filament. The energy expended being entirely transformed into radiations (we suppose, as is almost the case, that the losses by radiation and conductivity may be disregarded), will evidently be in proportion to the radiating surface; we get then

$$i^2 r = A\,\pi\, d\, l = c\, d\, l$$

for the energy expended per unit of time.

Also:

$$r = \rho\,\frac{l}{d^2}.$$

By substitution, we get:

$$i = \frac{c}{\rho} d^3 = m\, d^3,$$

from which we deduce the diameter of the filament:

$$d = m\, i^{\frac{2}{3}}, \qquad (4)$$

which must be employed in order to obtain a lamp consuming η watts per candle.

The surface, for a given emissive power and temperature, should be in proportion to the luminous power. Thus we get:

$$\pi\, d\, l = M\, b,$$

from which we deduce:

$$l = \frac{M}{\pi}\,\frac{b}{d} = n\,\frac{b}{d}. \qquad (5)$$

The constants, m and n, of formulæ 4 and 5, will have to be determined by experiment; they depend on the nature of the filament employed, *i.e.*, on its specific resistance and its emissive power. For these formulæ to be applicable, therefore, the filaments for the same type of lamp must all be of a similar nature; otherwise lamps constructed according to these equations would give widely different results as regards luminous power, brilliancy, and consumption. This was observed at the beginning of this industry, and was the cause of great waste in the manufacture of the lamps. We still find in the market lamps bearing the same mark which, for a given luminous power, vary considerably in brilliancy, thus affording in themselves a proof of careless manufacture.

(*To be continued.*)

THE EVOLUTION OF THE TYPEWRITER.

Cantor lectures at the Society of Arts are noted for their practical character and the lucid exposition of the subjects dealt with. We have recently given Captain Abney's course on "Photometry" in brief, and although the series now in progress on "Typewriting Machines" does not appeal so closely to electrical readers, it still deserves mention inasmuch as names holding an honoured place in electrical science are included in the list of inventors in this branch. Typewriters are also being brought into very general use by leading telegraph companies, and the typeprinting telegraphs, so largely patronised by those operating on the Stock Exchange or on the turf, are special applications of the same class of machines. Mr. H. C. Jenkins, in his first lecture, dealt with the early history of the typewriter, and characterised the machine generally as an apparatus by which printing could be executed without the laborious and costly operation of setting or composing from individual pieces of type. Type-writing is a misnomer; what is done is to print, and typewriting is really a special phase of the much more general and larger subject of printing. The early typewriters were designed almost without exception for the use of the blind, and were intended as a ready means by which those who had lost their sight could communicate by embossed signs on paper with one another. The machines used for this purpose were therefore, as a class, embossing machines, and the earliest attempts to produce what is now the typewriter had this end in view. One of the earliest workers was a Mr. Miles, a civil engineer connected with the New River Company, who in 1714 designed a machine of which, however, no record has come down to us. An embossing machine, of a similar kind, was devised by a French mechanic in 1784, while in 1844, a Fellow of the Royal Society, Mr. William Taylor, described Littledale's type-printing machine before the York meeting of the British Association, in whose journal a brief description will be found. The Littledale machine was, apparently, not unlike some of the simpler and cheaper machines on the market at the present time, and from the description probably would, if properly constructed, be found to work satisfactorily, if slowly. Newton, in 1846, and Charles Thurber, about the same time, patented machines, the latter being true writing machines, inasmuch as the letters were not struck off but traced by a pencil operated by suitable gearing. The Great Exhibition of

1851 contained examples of machines which, in some cases, obtained gold medals, although the Chairman of the Committee of Jurors, in reading a paper the following year before the Society of Arts, did not mention any one of them, apparently considering that their importance lay rather in the combination of mechanism employed than in their application as machines. For the furtherance of business or the reduction of labour in the preparation of MSS., a Mr. Hughes exhibited a machine independently in the same year as that in which the exhibition was held, and in his machine for the first time a true type printer appeared. In general form it resembled a horizontal axle carrying a type wheel set at right angles. Underneath, a frame held the paper upon which a communication was to be printed, and when any letter was required an index was brought round to a point or marker, the barrel was then depressed and an impression taken. Other forms were introduced in 1854 and 1856, but the greatest advance was made by Sir Chas. Wheatstone, who, in 1855, produced his first machine, and in the years following that date added improvements so that by 1860 no less than six practical machines had been turned out, of which several remain in working order at South Kensington Museum. In the later patterns the type is carried by the sector of a circle, and the motion is given by keys, which withdraw catches, allowing the sector to move round to the required position. In this machine a paper carrier, similar to that employed on a steam indicator, was used; inking pads were also provided, and the whole arrangement was a marvel of ingenuity, considering the date of construction. In other forms the sector was placed horizontally, and the keyboard partook of the nature of that of a piano, but the touch was found to be too heavy for the purpose of a writing machine. After this Beach introduced typeboards and Dr. Francis a release key, while Thomas Hall in 1861 is said to have actually made a typewriter which could be operated at a speed of 460 letters per minute. In 1869 Mr. Pratt read a paper before the Society of Arts, in which he described a typewriter possessing some novel details, and with his paper and the commencement of a new decade we reach the dawn of the commercial era, when the typewriter became a practical apparatus for everyday use and began to compete with the pen. The end in view was no longer the embossing of characters to be read by touch, but the printing of letters as rapidly as possible. This alone led to an entirely new line of development, which was dealt with in the second lecture.

THE CONNELLY MOTOR v. ELECTRICITY FOR DRIVING TRAMCARS.

By SYDNEY F. WALKER.

Considering the rapid advance that has been made in all branches of electrical engineering, and in the utilisation of electricity for the service of man, during the past fifteen years, it would have been surprising if its advance had not been challenged, from time to time, by would-be competitors. Accordingly, we are constantly being presented with new forms of apparatus, designed to accomplish all that electrical apparatus does, often with a lower first outlay, and always, so it is stated, with a considerably lower maintenance cost.

Some years back, when the telephone monopoly was at its hardest, we had the mechanical telephone.

A few years after, before the glow lamp had fairly established itself in public favour, we had the Welsbach incandescent gas burner.

Now, we have the Connelly motor, striving to snatch from electricity, a field that electricity has hardly been able to thoroughly explore, as yet, in this country.

The introduction of these apparatus is rendered more noteworthy, perhaps, from the fact that even electrical engineers who think, would admit that at the time of their introduction, the different apparatus mentioned, and many others, had apparently a far better chance of success, within certain limits, than the electrical apparatus they were designed to displace. Yet the result in every case that has gone before has been the same, the apparatus that was to oust electricity has itself been obliged to make room, and has at best—an honoured best—led up to the use of the rival it was to displace.

And in the present case, the writer ventures to prophesy another will but be added to the number of torches lighting the road for the advancing conqueror.

The present case is also very similar to those that have gone before, in that the inventors of the Connelly motor are perfectly justified in hoping to be able to capture the tramway and light railway field—before electricity can put in an appearance.

Professor Kennedy, in his presidential address to the Institution of Mechanical Engineers, has not exaggerated the case against electricity for tramways in the smallest degree.

Of the three methods that may be employed for driving tramcars by means of electricity, the overhead trolley method is the only one that can hope to compete with our old servant, the horse, and to show a reason for changing from horse traction to electricity.

The underground conduit plan involves considerable capital expenditure, is uncertain in work, and more expensive than horse traction in maintenance.

The accumulator method, *the* method *par excellence*, in the writer's opinion, when the time has arrived, also involves a considerable initial outlay, is more expensive in maintenance than horse traction, and also has the unique disadvantage that it is not possible to place sufficient accumulators on a fully loaded tram car, to enable it to start, on a wet day, if the gradient is over 1 in 20. So that, apparently, if the Connelly motor will do all that its promotors promise, it will do what electricity in its present stage of development will not, and therefore it should be able to hold its own against the young giant who has so far vanquished all opponents.

Let us consider, however, what are the chances of success of the Connelly motor. What has it accomplished? The Connelly motor consists of a pair of oil engines developing about 12 brake H.P., carrying an oil tank above the engine cylinders, the oil in which is heated by the water that has passed round the engine cylinders; and of a special method of transmitting the energy generated by the crank-shaft of the engines to the driving axles of the cars.

In the first place, it is somewhat naïvely reported by one of the experts employed, that in his opinion it would be impossible to run a tramcar with an oil or gas engine, but for this method of transmitting the energy to the driving axles. Therefore, if this method of transmission fails, the whole scheme fails.

What is the method? One that the writer believes is well known to mechanical engineers and very rarely employed. One that presents very grave difficulties in point of maintenance where the conditions are most favourable; where a skilful mechanic can always have his eye on the wearing surfaces, seeing that they are kept free from dirt, well oiled, and any wear instantly taken up.

A method that in ordinary tramway or light railway work would be almost certain to fail.

The method employed is as follows:—On the crank-shaft of the engines revolves a disc about 30 inches in diameter, and against this disc presses a pulley whose position, radially to the disc, can be altered at the will of the driver. The power is communicated from the disc to the pulley simply by friction. Any wear of either, tending to lessen the friction between the two will mean slip, loss of power, and that there will be wear is inevitable.

No measurements appear to have been taken either as to the loss in transmission by means of this friction gear; either when at its best, when wet, or when clogged with dirt. The writer ventures to think that a few experiments on this question would furnish rather startling results.

It will be noted, too, that the very ingenious plan is adopted of utilising the heat generated in the engine cylinders and communicated to the water circulating round them for raising the temperature of the oil itself, so as to more readily convert it into oil gas.

But what chances are there of this not working properly in very cold weather. The above are only a few, a very few points that strike one on reading the prospectus of the company that is being floated to work the Connelly patents. Many more will doubtless occur to readers of this article. But the point the writer wishes to bring out is, that with the Connelly motor, as with other apparatus, electrical engineers have only to go steadily on improving their

apparatus, and in due course this motor, even if successful now, will be obliged to give way to electrical motors when electrical engineers are ready; and, meanwhile, electrical engineers should cordially welcome its advent if it will educate consumers to require a better apparatus than those at present in use.

THE ANTWERP EXHIBITION.

By FREDERICK BATHURST, A.I.E.E.

Probably many readers of the Electrical Review who are yet undecided as to how to spend the summer vacation will, at the last moment, take advantage of the exhibition which is to be shortly opened in Antwerp and visit this town. To these, and to those who have already decided to cross the "silver streak," perhaps a few pointers coming from one who has recently returned from an advance pilgrimage to this part may be useful and interesting.

Whilst doing the round of sights, the electrical visitor will hardly fail to notice in the Place Vert, a glass enclosed structure which contains turbines and dynamos, and to find out that it is the pioneer distributing station of the Hydraulic Electric Company, which will eventually supply light and power to the whole city. A notice of the engineering details of this interesting plant has recently been published, but Messrs. Moris and Cornand, the director and engineer respectively, will courteously place all particulars of the installation before those interested, and issue a permit to view the central station. The idea is to distribute water at a very high pressure, 52·5 atmospheres (770 lbs.) through the town, and utilise it by means of turbines, either for power direct, or for driving dynamos for lighting. It is maintained that this method will, in the case of Antwerp, be cheaper than a purely electrical distribution, and all conflict with the City Council regarding the disposition of high potential electric mains thereby avoided.

The operation of this plant will be watched with much interest, and a practical example of its possibilities will be found in the exhibition itself, as the whole of the lighting effects in "Old Antwerp" has been entrusted to this company.

As regards the exhibition proper, the first 10 days of last month found the authorities in just the same plight as those of each and all exhibitions that we have yet seen, within a month of the opening day, and many of the buildings that were to contain exhibits not then out of the workman's hands. This month will have been one full of work and anxiety, both to the authorities and exhibitors.

A walk through the grounds confirmed the idea that most of this exhibition will be under cover, and that it will be able to defy the most unpropitious weather. The ground surface to be taken up amounts to 360,000 square metres (88 acres), whilst only 80,000 square metres (19·5 acres), is devoted to garden promenades.

To judge from the state of affairs in the engine-room, this will not be what may be designated a "heavy" exhibition, and, although the educational effect of a great engineering feat may be present, whatever machinery is eventually to be put down, at that time not a single engine foundation had been *completed*, and of the large machinery a single paper machine stood near the entrance, the solitary piece yet erected.

True it was that conduits had been cut and were waiting for the shafting, steam pipes, and electric cables that were to be placed in them, but without overhead travelling cranes, and with only the small portable single-arm steam cranes moving over temporary rails, hurried work in this department must result, even if the opening had been delayed a month longer. It is not for me to criticise the well-considered plans of the administration, but it would seem that the want of an overhead travelling crane in the engine room will have been the greatest drawback the authorities have had to face in their wish to open a complete exhibition "on time." The building, as constructed, would not allow of the erection of such a crane, and natural conditions will not help the mechanical engineer, for the soil is a sandy loam which necessitates foundation excavations to a depth of four to six feet. The foundations being put down consisted of two or three feet thickness of cemented brick at the bottom, and the remainder built up with heavy cross and transverse wood beams.

When the backwardness of the engine-room and the gardening work has been noticed, the worst has been said.

The official buildings—already completed—will stand conspicuous monuments as showing how Belgian engineers can cover a large space with the smallest amount of material. The interior ironwork is indeed spider-like, and American constructors who have hitherto claimed the palm in this respect, will, when they visit these buildings, doubt their present superiority and express surprise as to the lightness and elegance of the construction.

Large quantities of wood protected with the now familiar "staff" is employed for covering in and for outside ornamentation. Within the buildings thought and consideration was manifested for the labour in front of the exhibitors whose goods were all in warehouse or lying in the railway yards, by the provision of the Le Grand system of portable railway. The iron tracks for this system are so quickly laid to any point that doubtless this will solve the problem as to how to fill the empty halls with crates, and remove the superfluous lumber resulting therefrom in time for the opening day.

The grounds outside the buildings although chaotic at the time of my visit, every pathway and grass plot being covered with lumber and building material, have doubtless by this time taken their proper appearance. The arc lamp poles were all in position, and are another index of the effective, but utilitarian and economical spirit prevailing with the authorities. These poles consist of a light centre post or pipe stayed all round with six iron wires which, before reaching the ground plate where they are fastened, pass over two or three star plates, which act as struts to the centre pole. Where a bracket arm is used the hoisting cable passes through the centre of the pole. They are very light and graceful in appearance, and must be cheap as well as efficient.

There are within the Exhibition grounds many "side shows," to which admission will be an extra, and probably the most interesting will be "Old Antwerp."

This will be in the nature of "Old Vienna," which was so successful at Chicago. Articles will be sold there which may or may not be indigenous to Antwerp itself, but the fair vendors will all be arrayed in the costumes of by-gone days, and in addition to the music and the entertainment provided by the efforts of the salespeople to find customers, there will be reproductions of many interesting customs.

"The village" will have interest for the electrician, as all the lighting is to be done with arc and incandescent lamps (20 arc and some 1,800 5-C.P. incandescent) concealed within old-fashioned lamps and candlelabra. Those interested in obtaining new designs for antique iron-work fittings will find this a fertile field to draw upon.

Many other attractions will make it easy to spend the freely flowing franc, for American enterprise is responsible for the Mammoth Crystal Cave, a Boynton diving exhibit, and a Pantechnicon; whilst the Asiatics, who do not let slip a chance for *honest gain*, are working hard upon the construction of a Quartier Syrien (Turkish), Tunis and Algiers, Le Continent Mysterieux and an Oriental Labyrinth. A miniature "Rue de Cairo" is taking shape from wood and plaster.

The dirigible balloon enclosure was practically finished and should prove a profitable investment to its organisers.

The price of admission to the grounds will be *one franc*, or forty francs for the season ticket, whilst probably a *fifty-franc note* will enable the undaunted excursionist to see the whole of the sights provided.

The exhibition will be in the French style, light and artistic, and although something of the educational nature may be lost, the deficiency will be made up with music, colour, and pictures, the magnificent gallery of the old Flemish school being included within the grounds.

Perhaps, as Mr. George Augustus Sala says of exhibitions in general, there will be too much noise, too much dust, too much eating, drinking, and extortion, in fact, too much everything; but I believe every visitor will find it worth while seeing, and retain a lively sense of gratitude toward the heroic lady who is now standing at the base of the main dome holding a banner in her outstretched arms, upon which is inscribed the one word "Welkom."

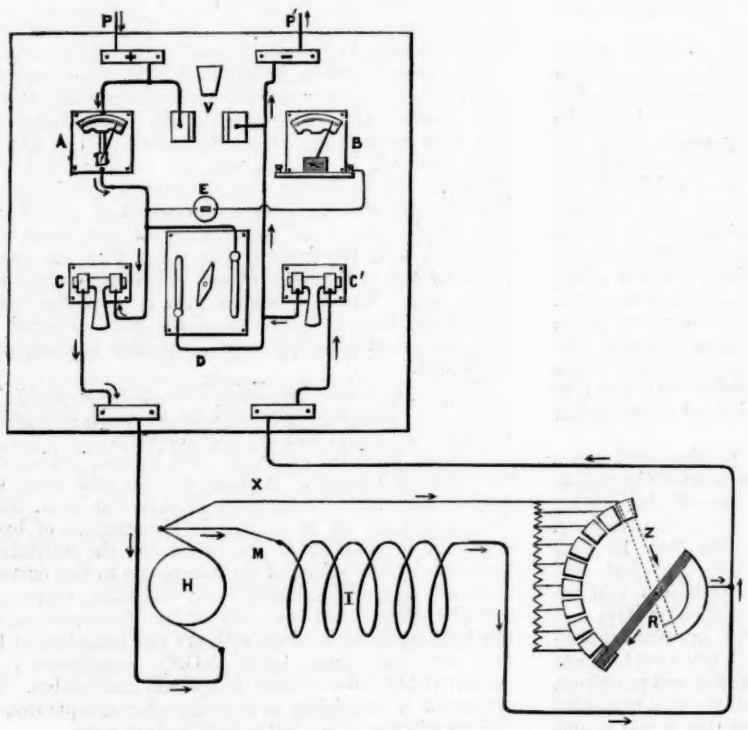
THE ELECTRICAL SUB-STATIONS OF THE PARIS COMPRESSED AIR COMPANY.*

By J. LAFFARGUE.

Certain changes are now being made by the Paris Compressed Air Company in the installations originally established by them for the distribution of electrical energy throughout their sector. Amongst others, we may mention the employment of continuous current transformers in the place of some of the batteries of accumulators which, until now, have effected the entire service. The primary circuit of this transformer, connected in circuit with the primary circuits of other stations, receives the high tension electrical energy from the Saint Fargeau works, or from the Boulevard Richard Lenoir, acts as a motor, and works a low tension generating dynamo (120 volts). The same arrangements are adopted in all the sub-stations in Paris, 25 in number; we will now give some particulars relating to the new sub-station of the Bazar de l'Hotel de Ville, the fitting up of which we had an opportunity of inspecting, M. Laforge, the engineer in charge, having kindly furnished all the information we required.

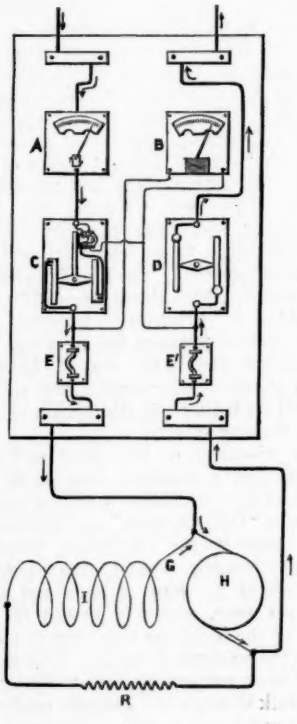
Accumulators and Continuous Current Transformers.—The sub-station contains two batteries of 67 accumulators, supplied by the Society for the Electrical Working of Metals, of a capacity of 2,500 ampère hours, and two continuous current transformers. The accumulators are intended to ensure the steadiness of the voltage, and to replace the transformers if necessary. These latter are two in number, one of 70 kilowatts and the other of 33 kilowatts. They consist of two Thury dynamos with six poles, and with field magnets of wrought-iron. They are coupled together by means of a Raffard joint. Each dynamo has a special board on which are arranged the apparatus required for the various manipulations. The motor is excited in series, the generator is shunt excited. The intensity in the primary circuit of the transformer of 33 kilowatts may amount to 275 ampères under 175 volts, and 300 ampères under 110—120 volts at the angular speed of 550 revolutions per minute. For the 70-kilowatt model, the constants are 340 volts at 275 ampères in the primary circuit and 110—120 volts, and 640 in the secondary circuit at the angular speed of 450 revolutions per minute.

Distribution Boards.—Figs. 1 and 2 show the plans of the distribution boards, the first placed on the high tension circuit (2,500 volts) and the second placed on the low tension distribution circuit (120 volts). The instruments are arranged on boards highly polished, so as to be easily kept very clean, and with a sufficiently high insulation resistance. At P and P′ (fig. 1) are the two arrival wires of the high tension circuit. The current passes through an ampèremeter, A, a key, C, serving as an interrupter, the armature, H, of the motor, M, and the field magnets, I; part of it passes through the cable, X, into a graduating rheostat, R. The circuit is then closed by a key, C′, which is connected with the departure wire, P′. Several other instruments are placed in the shunt circuit. At V is an automatic alarm, which should be opened during the normal service; when an accident happens, or when the difference of potential rises above its normal value, a fine wire solenoid attracts a lever of soft iron, which establishes a short circuit along the line. At B is a voltmeter with a fusible circuit-breaker, E; at D is an interrupter, which enables the sub-station to be short circuited at the time of the stoppage.



High tension board. A, ampèremeter; B, voltmeter; V, alarm; E, lead; C C′, keys; D, short-circuit interrupter; M, motor; H, armature; I, series magnet; R, regulating rheostat.

Fig. 1.—Sub-Station. Primary Circuit. High Tension.



Low tension board. A, ampèremeter; B, voltmeter; C, automatic disconnector; D, interrupter; E E′, lead; G, generator; H, armature; I, shunt magnet; R, field rheostat.

Fig. 2.—Secondary Circuit. Low Tension.

The low tension board (fig. 2) comprises an ampèremeter, A; a voltmeter, B; an automatic cut-out, C; an interrupter, D, and some fusible circuit breakers, E and E′. A rheostat with regulator, R, enables the resistance of the shunt excitation to be varied at will. Another general board enables the station to be short-circuited at any given moment in case of accident, or each of the transformers to be insulated in succession, equivalent resistances being substituted for them.

Various Manipulations.—The manipulations to be effected in a sub-station of this kind are: 1. The starting of the transformers for the main service, utilising, if necessary, the discharge of the accumulators to make up the sum total of the power to be distributed. 2. Stopping the transformers

* *L'Industrie Electrique.*

after the main service. 3. Charging some of the accumulators, and discharging others.

In order to start the transformer, the alarm, V (fig. 1), is opened, the keys, C and C′ are put in place in the contacts, the rheostat, R, is at the bottom of its course, at Z, *i.e.*, out of the circuit. The interrupter, D, is then opened. The general circuit of the motor is closed, and the current passes through the amperemeter, A, the key, C, the armature, H, and the cable, X. By varying the resistance, R, the motor, M, is started, and we have only to regulate this resistance, in order to give the generator, G (fig. 2), the speed required. When the difference of potential has attained its normal value, the automatic disconnector, D, is closed, and the resistance, R, regulated.

If at a given moment the power expended in the outer circuit exceeds that produced by the transformer, one or two batteries of accumulators are coupled in quantity with it.

To stop the transformer we begin by decreasing the resistance, R (fig. 1), of the motor, so as to slacken its speed. When the difference of potential falls to 0 on the distribution board (fig. 2), the interrupter, D, is opened; the interrupter, D, on the first board (fig. 1) closed, and the keys, C and C′, turned back.

We may also mention that automatic rheostats, with regulators acting by centrifugal force fixed on each of the transformers, enable the secondary difference of potential to be kept constant.

We need not describe the charging or discharging of the accumulators on the high tension circuit, as these operations are now well known.

These new arrangements adopted by the Paris Compressed Air Company seem to give very satisfactory results; the industrial efficiency of the transformers when fully charged attains to 80 per cent.

CURRENT WITHOUT DIFFERENCE OF POTENTIAL.*

By A. G. WEBSTER.

The trouble in the matter generally proceeds from a misapprehension of what potential and electromotive force really are. Difference of potential implies a disturbance of the distribution of charge from the state of equilibrium, requiring work to produce it, but not to maintain it. In order to maintain it a counterbalancing electromotive force is necessary; otherwise the charges will flow back, causing a current. Now an electromotive force may act continuously with or without a difference of potential. Ohm's law tells us that the current in a conductor between two points is proportional to the electromotive force in the conductor between them plus the difference of potential or "drop," between them. If the electromotive force is equal and opposite to the drop, there will be no current. If, on the other hand, there is an equal electromotive force generated in every unit of length all around the circuit, there will be no difference of potential; the case of a ring, or of a symmetrical solenoid closed on itself with a magnet thrust into it, or with another solenoid forming a transformer, is another.

Perhaps the subject is made simpler where the electromotive force is not due to induction, and is not continuous in the conductor. Consider a single cell of a battery. If we represent the potential of different points in the circuit as ordinates to abscissæ representing resistances measured from a fixed point of the circuit, we get a straight line whose slope represents the strength of the current. At some point in the cell the potential rises abruptly by the amount A, B, fig. 1. Consider now two cells, each of half the former electromotive force, the whole resistance of the circuit being the same as before. The current is the same as before, but the greatest difference of potential between any two points is now represented by E, D, fig. 2, and is less than before. Consider now any number of cells, say six, each of one-sixth the original electromotive force, connected in a ring; without external resistance, the total resistance being still the same. The current is the same as before, but the maximum difference of potential between two points is only A, B, fig. 3, one-sixth as much as at first. Consider now a great many cells so connected, the total electromotive force and resistance being the same, hence the current also, while the difference of potential between any two points is extremely

Fig. 1.

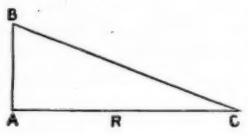


Fig. 2.

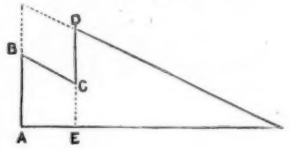


Fig. 3.

small, and in the limit zero. Thus we see how, when the electromotive force is continuously distributed, we may have a current as large as we please, without difference of potential. In all the figures the oblique lines are intended to have the same slope.,

* Abstract from *Electrical World*.

SOME IMPROVEMENTS IN ELECTRIC SMELTING.

Electric smelting is perhaps the youngest of the side applications to which electrical energy has been commercially put, but judging from its recent developments it bids fair to rival in its progress-pace every other adaptation. Amongst the most recent improvements in this direction the following appear worthy of special notice.

It will be borne in mind that electric furnaces are divisible into two classes, viz.: (1) incandescent furnaces, where the current passes through a mass of broken carbon; and (2) arc furnaces, where the current passes across an arc between two separated electrodes. In the former the poles are placed horizontally; in the latter usually vertically; the refractory ore becomes fused when the current passes, and a pool is formed at the bottom of the crucible. The molten matter, as those who have had experience of such plant are aware, is very apt to splutter or foam at frequent irregular intervals, and this boiling-up of the mass short-circuits the arc and lowers the resistance of the furnace, thereby seriously affecting the operations of the dynamo.

By a new improvement, due to an American engineer, T. L. Wilson, the "boiling-up" and short-circuiting may be prevented in arc furnaces by commingling with the metallic ore finely-divided or pulverised carbon. The violent fluctuations in the resistance of the arc that would otherwise occur are consequently avoided, and injurious strains of the plant are claimed to be obviated.

The principle here laid down is in reality at the base of another improvement which is specially designed for the treatment of aluminous and similar refractory ores. The raw ore, after having been crushed and dried, is mixed with hot pitch, coal-tar, paraffin, or heavy hydro-carbon oil, and then heated until the mass is practically a dry granulated powder. It is then ready to be fed into the furnace. It is stated that this treatment greatly facilitates the reduction of the ore.

In smelting certain kinds of refractory ores, it is a disadvantage for the air to come in contact with the heated mass. To obviate this R. Niewerth has constructed an electric furnace, which is air-tight, the electrodes passing through stuffing-boxes. This principle prevents oxidation, an effect which too frequently renders electric smelting expensive and wasteful. In this furnace inlet and outlet pipes are provided for gases, with a hopper furnished with a water seal at the top of the furnace to supply fresh material. When smelting copper, this arrangement permits the process to be conducted

in an atmosphere of carbon monoxide, which absolutely prevents oxidation.

Those who are interested in the electrometallurgy of that over-much bepuffed metal, aluminium, will find a noteworthy review of its recent progress in *Dingler's Polytechnisches Journal*, cclxxxix., pp. 129—135. All the best methods of manufacture are discussed and criticised in the style of one who has *not* "an axe to grind." This fact of itself would make the paper worth perusal. It is refreshing to read something really unbiassed and judicial in tone about aluminium. To this paper another may be added, for study, by A. H. Bucherer, entitled "Modern Processes for the Manufacture of Aluminium," for which consult the *Zeitschrift für Angewandte Chemie.*, xvii., pp. 515—517.

HOWES'S ELECTRIC LAMP PENDANT.

This arrangement, the invention of Mr. A. J. Howes, has for its object the production of a standard pendant which may be lengthened or contracted at will, without the employment of chains, weights, or other cumbrous counterbalances, and is also capable of lateral movement in any direction, so that in any case of its adoption the point of light may be raised, lowered, extended, withdrawn, or angularly directed, according to requirement. Also, the connections of the lamp with the main leads or branches are effected without soldering, and are completely insulated from

the metallic body of the device, and are not liable to deterioration or injury by reason of the several movements.

In the arrangement which is shown by the figure there are two or more tubes, the first being attached to a suitable base-plate, and the other moving telescopically within it, and the next within this, and so on to the extent of the series; the arrangement, however, is such that when closed the length is that of the first tube. A collet is fixed to the extreme end of each tube, fitting within another, thus enlarging the end to fit the tube; the enlargement is split at one or more points in its circumference in a direction parallel to the axis of the tube, by a saw slit, so that the outward spring thus afforded may cause sufficient grip upon the external or containing tube to retain the weight of the lamp and fittings at any desired point.

The last tube of the series is furnished with a screwed collar, the internal bore of which is coned or tapered, the collar being fitted upon its screwed outer surface with a cap which is tapered internally in an opposite direction to that of the bore of the collar. The two have between them an hemispherical hollow cup, terminating in a hollow stalk carrying a lampholder. This arrangement allows of the latter being diverted angularly in any direction, and held in position by a slight tightening of the cap upon the screwed collar. The wires pass from an ordinary lampholder connections through the stalk and series of tubes, being coiled spirally to admit of the longitudinal extension and contraction, and terminating at an insulated plate, provided with screws for connecting to the leads within the base plate. The shape of the hollow cup and its enclosing cones, admits of lateral or angular movement without damaging the wires.

ELECTRICAL HEAT IN THE CHEMICAL INDUSTRIES.

Whilst the heating of dwelling-houses and the cooking of food by means of electricity are, for the most part, only regarded as scientific curiosities, the application of this form of energy to the generation of heat for use in the manufacture of chemicals is rapidly becoming *un fait accompli*. It is not to be wondered at, perhaps, that the average Britisher, than whom none is more conservative about his meals, should look askance at electrical cookery. We may remind him, however, that—but a little while ago—of gas he would have none of it; and now there are few houses without a gas-cooking stove. In the natural course of evolution gas will be replaced in the kitchen by electricity. That is the only logical conclusion which can be arrived at from a review of our previous experience.

In Germany, recently, we learn from the *Chemiker Zeitung*, the use of electrical heat for the concentration of sulphuric acid has been adopted. Sulphuric acid, as everyone should know, is one of the most important of chemical productions. In fact, a celebrated chemist once said "You may measure a nation's prosperity by its output of sulphuric acid." Now, in order to produce 100 kilos of 66° acid it is necessary to concentrate 117 kilos of 60° acid—the latter strength being that usually produced by most methods of manufacture, and the former the strength demanded in commerce. Taking this as having a temperature 18° C. to begin with, and the concentrated acid as being at 330° C. to end with, and, further, assuming the specific heat of the acid to be 0·33, the heat consumption during the heating up and evaporation will be as follow:—

	Calories.
1. Heating 66° acid from 18° to 330° C.	10,296
2. „ acid, evaporation of 17 kilos water ...	12,383
3. Heat evolution during union of 60° acid with one-and-a-half H_2O, forming 66° acid ...	10,000
	32,679

Hence $32{,}679 \times 4{\cdot}2 \times 10^3$ watts per second are required, or, $\frac{32{,}679 \times 4{\cdot}2 \times 10^3}{736 \times 3{,}600} = 44{\cdot}2$ horse-power per hour; or allowing for loss of heat by radiation, &c., from the retorts, about 50 horse-power per hour.

To accomplish this by means of electricity will cost about £1 per ton, admitting the practical cost of the current to be 0·04 mark per hour horse-power. This appears to be a great saving on the cost per ton for concentration by any other form of heat yet applied to this purpose.

The resistance of platinum wire, a substance unaffected by sulphuric acid, is used for localising the heat. In order to calculate the dimensions of such a wire, capable of furnishing the requisite heat, it is assumed by Bucherer, in

the *Chemiker Zeitung*, that the mean temperature of the wire is 150° C. higher than that of the acid, *i.e.*, is 480° C. This amounts to supposing that with this excess of temperature of metal over that of acid, the rate of passage of heat into the acid is just as rapid as its rate of generation by the current.

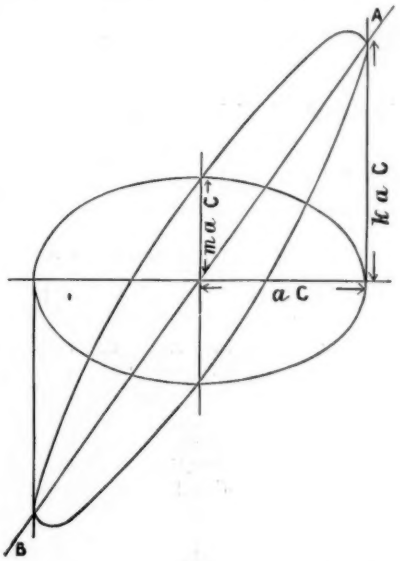
If the difference of potential between the ends of the wire be 5 volts, a current of 364 ampères will develop in a wire 0·5 cm. diameter and 77 cm. long, 2·4 electrical units; hence, in the course of 5 hours, 12 units are produced competent to concentrate 24 kilos of 66° acid (starting at 60°) in a vessel suitably jacketed to minimise loss by conduction, &c.

It does not appear to have been quite decided yet whether it is cheaper in practice to use a weaker current for a proportionately longer time, or *vice versâ*. The calculations indicate, at least, the probability that electrically generated heat may be very economically applied, not only in the concentration of sulphuric acid, but of other liquids which demand concentration before being put upon the market. In the matter of convenience, those who are acquainted with the technique of vitriol making will perceive at once the great superiority of electrical concentration. In Canada electrical heat has recently been successfully employed in the concentration of acetic acid.

ALTERNATING CURRENTS AND HYSTERESIS.

By ARTHUR WHITWELL, M.A., A.R.C.Sc.

In most theoretical investigations into the action of transformers or other apparatus in which the currents, E.M.Fs., &c., are alternating, it is, for the sake of simplicity, customary to assume that the induction produced by a current flowing, say, in a coil, is directly proportional to the current. This is perfectly correct when the medium supporting the induction is air or some other substance, the permeability of which is a constant, but it is not correct when the medium is iron. The permeability of iron is not a constant, in fact, it is a rather complicated function of the magnetising force to which the iron is subjected. Again, the permeability of iron corresponding to any particular magnetising force depends on the previous history of the iron as regards magnetisation, and has different values according as its state is reached from a previous condition of higher or lower magnetisation. This latter property has been called by Ewing, hysteresis. Suppose we start with a piece of iron saturated with magnetism in a given direction, then gradually reduce the magnetising force to zero and then gradually increase it in the opposite direction till the iron is magnetised to saturation in the opposite direction, and then completely reverse the process till the first state is again reached, the iron will have passed through a complete cyclic change, and if the magnetising force be plotted as abscissæ and the induction as ordinates, we should get the ordinary hysteresis curve, the $\frac{d\,y}{d\,x}$ or more properly the $\frac{d\,\mathrm{B}}{d\,\mathrm{H}}$ of which would give us the permeability. In ordinary calculations, the $\frac{d\,\mathrm{B}}{d\,\mathrm{H}}$ is taken to be a constant which is only true when the hysteresis curve becomes a straight line, in which case there is, strictly speaking, no hysteresis at all. Now, to take hysteresis into account it would be necessary to obtain the equation of the hysteresis curve, and differentiate it to get the $\frac{d\,\mathrm{B}}{d\,\mathrm{H}}$ which must be used for μ. It is very difficult to find an equation which more or less accurately fits the hysteresis curve, and if such a one were found it would probably be too complicated to be of much service. It is well known that what are called alternating currents do not follow the harmonic law accurately, but still some important results have been arrived at by investigations in which the sine law for the current has been assumed. Following this precedent it occurred to me that if we could find some curve, whose equation was well known, which approximated to the hysteresis curve, we could use it and perhaps obtain some more or less useful results. The first curve that suggests itself is the ellipse on account of its close connection with the circle, and consequently to the sine curve which we shall assume for the current. If we draw an ellipse with the origin as centre, and with the major axis inclined to the axis of x at about 60°, the minor axis being small, it will be found that a great part of it approximates very closely to the true hysteresis curve. The cusps are absent, and the maximum x does not quite correspond with the maximum y, as it does in the true curve. The above mentioned ellipse corresponds much more closely with the true curve than does a straight line, and the results arrived at by using it should be much nearer the actual truth than those arrived at by assuming the permeability to be a constant and the hysteresis curve a straight line.



However, we can investigate the effects of using an elliptical hysteresis curve and take the results for what they are worth. Let us suppose a coil of N turns, and of resistance, R, to be wound on a closed iron circuit of length, l, and area, A, and let a current of C sin $p\,t$ flow in the coil. Absolute units will be used. The maximum value of the magnetising force $= 4\,\pi\,\mathrm{N\,C\,A}/l$, put this $= a\,\mathrm{C}$. Let the induction corresponding to maximum current be $\pm\,k\,a\,\mathrm{C}$, and that corresponding to zero current to $\pm\,m\,a\,\mathrm{C}$. Draw an ellipse (see fig.) with the centre as origin, the semi-major axis being along the axis of x and $= a\,\mathrm{C}$, the semi-minor along the axis of y and $= m\,a\,\mathrm{C}$. Draw a straight line, A B, whose equation is $y = k\,x$, and add the ordinates of ellipse and straight line to get a new ellipse, which will be assumed as the hysteresis curve. The equation of the first ellipse is

$$\frac{x^2}{a^2\,\mathrm{C}^2} + \frac{y^2}{m^2\,a^2\,\mathrm{C}^2} = 1,$$

and of the second

$$y = \pm\,m\,\sqrt{a^2\,\mathrm{C}^2 - x^2} + k\,x;$$

y is the induction corresponding to a magnetising force, x, so, putting in the value of x, viz., $a\,\mathrm{C}\sin p\,t$, we have

$$\mathrm{B} = -\,m\,a\,\mathrm{C}\cos p\,t + \mathrm{K}\,a\,\mathrm{C}\sin p\,t \qquad (1)$$

the $-$ sign is used because when $t = 0$, $\mathrm{B} = -\,m\,a\,\mathrm{C}$, and when $t = \frac{\mathrm{T}}{2}$, $\mathrm{B} = m\,a\,\mathrm{C}$.

(1) may be written by an easy transformation

$$\mathrm{B} = a\,\mathrm{C}\,\sqrt{m^2 + k^2}\sin(p\,t - \theta) \qquad (2)$$

where

$$\tan\theta = \frac{m}{k}.$$

This equation (2) shows that the induction is a sine function of the time, the maximum value being $a\,\mathrm{C}\,\sqrt{m^2 + k^2}$, and is an angle θ behind the magnetising force or current. When the magnetising force is $= 0$, $\mathrm{B} = \pm\,m\,a\,\mathrm{C}$, this is the residual magnetism. When the induction is $= 0$, the magnetising force $= \pm\,\frac{m\,a\,\mathrm{C}}{\sqrt{k^2 + m^2}}$, this is what Dr. Hopkin.

son has called the coercive force. As, from (2), $\frac{d\,B}{d\,t} = p\,a\,C\,\sqrt{m^2 + k^2}\cos(p\,t - \theta)$, and $\frac{d\,H}{d\,t} = p\,a\,C\cos p\,t$,

$\frac{d\,B}{d\,H}$ or $\mu = \sqrt{m^2 + k^2}\,\frac{\cos(p\,t - \theta)}{\cos p\,t} = k + m\tan p\,t.$

The E.M.F. required in the above-mentioned case will be

$= C\,R\sin p\,t + N \times$ rate of change of induction.

$= C\,R\sin p\,t + N\frac{d\,B}{d\,t}.$

$= C\,R\sin p\,t + p\,a\,C\,N\,\sqrt{m^2 + k^2}\cos(p\,t - \theta).$

$= C\,\{(R + a\,p\,N\,m)\sin p\,t + a\,p\,N\,k\cos p\,t\}.$

$= C\,\sqrt{(R + a\,p\,N\,m)^2 + (p\,a\,N\,k)^2}\sin(p\,t + \theta^1).$

where $$\tan\theta^1 = \frac{a\,p\,N\,k}{R + a\,p\,N\,m}.$$

If the impressed E.M.F. be $= E\sin p\,t$, then

$$C = \frac{E}{\sqrt{(R + a\,p\,N\,m)^2 + (p\,a\,N\,k)^2}}\sin(p\,t - \theta^1) \quad (3)$$

Comparing this with the ordinary equation

$$C = \frac{E}{\sqrt{R^2 + p^2\,L^2}}\sin(p\,t - \theta) \quad (4)$$

$\tan\theta = \frac{p\,L}{R}$, and remembering that $a = 4\,\pi\,N\,A/l$, and $L = 4\,\pi\,N^2\,A\,\mu/l$, we see that the second terms under the roots in the two expressions are identical; also that the effect of hysteresis is to apparently increase the ohmic resistance by an amount $4\,\pi\,N^2\,A\,p\,m/l$, which is directly proportional to the frequency and to the residual magnetism; also that when $m = o$, the expressions are identical; also that the angle of lag of the current behind E.M.F. is diminished, the numerator of the tangent remaining the same, whilst the denominator has been increased.

The watts using equation (4)

$$= \tfrac{1}{2}\,\frac{E^2\,R}{R^2 + p^2\,L^2}$$

using (3), with hysteresis taken into account,

$$= \tfrac{1}{2}\,\frac{E^2\,(R + a\,p\,N\,m)}{(R + a\,p\,N\,m)^2 + (p\,a\,N\,k)^2}$$

The first of these is $> = <$ than the second, as

$$R^2 + R\,a\,p\,N\,m > = < p^2\,L^2.$$

The area of the elliptical hysteresis curve $= \pi\,m\,a^2\,C^2$, and is proportional to the residual magnetism.

It is often stated that even if the primary E.M.F. or current of a transformer were true sine functions, the secondary current would be distorted and not a sine function at all; the above investigation throws light on this point, and shows that if the medium supporting the induction possesses the property of hysteresis, an impressed harmonic E.M.F. will only produce a harmonic current, magnetising force, induction, and harmonic induced currents when the hysteresis curve is an ellipse, or circle or straight line, which are particular forms of the ellipse, and that the nearer the hysteresis curve approaches an ellipse, the nearer the induced currents, &c., are sine functions.

SMALL ARCS OR LARGE INCANDESCENTS?*

By ALBERT SCHEIBLE.

The discussion which has recently been started on the opening for small arc lamps, leads us to speculate on the apparent limitations of these as they decrease in candle-power, and the probable line of demarcation between them and the large incandescents. Indeed, it seems to me that we are viewing but one phase of the question when we consider the small arcs alone, as many of the arguments advanced in their favour hold equally well for incandescent lamps of higher candle-power than the ordinary. The shortcoming need not lie entirely in the old size of arc lamps, but may be in the whole series of electric lighting units, which shows an immense gap between the high candle arcs and the small incandescents.

The older workers who were familiar with the cry of a dozen years ago—"the sub-division of the electric light"—will remember how decided a want was met by the incandescent lamp, and how this immediately commanded the attention of electrical workers, it being even thought by some that the arc lamp was doomed altogether. And we, who have watched other pendulum-like tendencies in electrical developments, can see how the concentrated energy of a host of exploiters was easily turned from the large arc lamp to the far smaller incandescent, though the former has still held its own until both have come down to us side by side in their more perfected forms. Of course, there have been several sizes of incandescents, more particularly the 10, 16, 32, and some of 50 candles; and there have been arc lamps of 1,200, 1,500 and 2,000 C.P.; but, after all, these represent but two series of sizes near the extremes of the scale, while there really is a demand for all the intervening sizes as well.

So we are at last confronted with the fact that the needs of electric lighting call for a graded series of units, ranging all the way from 10 to 2,000 candle-power, there being at present a decided gap between the fifty and the thousand. That the small arcs will do much towards filling a part of this gap (perhaps all that lies above three or four hundred C.P.), seems evident from the more recent developments. But I think we must look to the incandescent lamp in its larger sizes for the rest. Of course the lower efficiency of the latter as compared with the arc lamp counts against it, but the efforts now being made by various investigators promise some practical results in raising this efficiency. The prolonged litigation over the vacuum lamps has driven many lamp makers to experiments along new lines, and some of their work may do much towards helping the large incandescents. What is more, the competition on the small sizes has narrowed the manufacturer's profit so much that he is on the lookout for other styles that leave him a better margin, and the few firms who are in a position to supply lamps of several hundred candle-power are already reaping some of the harvest. Happily, less is at present expected of these large incandescents as regards life for a certain efficiency, since they fill a line in which the consumers have not yet been spoilt. And even if the expectation of some of the experimenters—the production of a three hundred hour, one watt per candle lamp—is only partly realised, there still seems to be a good opening for incandescents in sizes up to three and perhaps four hundred candle-power.

In this connection it is interesting to note the comments of the Edison lamp expert, Mr. J. W. Howell, on Prof. Anthony's recent paper. When Mr. Howell remarks that the 16 and not the 32 C.P. lamp represents the best lamp making of to-day, can we not infer that there is still room for considerable development of the 50, 100, and 200 C.P. lamps? Mr. Howell's comments, and indeed the whole discussion of Prof. Anthony's paper tends to show that further perfection of the incandescent lamps may soon be expected, and I for one believe that the high candle-power lamps will get some of that attention which they have long been needing. Just where the line will be drawn between them and the small arcs remains to be seen, as the developments in methods of distribution by either direct or alternating currents lend themselves equally readily to both forms. Probably it will depend partly on the result of the work already mentioned, which involves the making of the filaments as well as the nature and density of the surrounding atmosphere. At any rate, we may expect to see the incandescent lamp entitled to a good share of the medium candle-power lighting which is now being exploited, so that we should not lose sight of it amid the stir over that timely newcomer, the small arc.

* The New York *Electrical Engineer*.

Electric Lighting of Trains in India.—It is stated that the Indian North Western Railway Company are considering the advisability of using the electric light on their trains.

RESEARCHES ON THE ELECTROLYSIS OF ALKALI SALTS.

It is satisfactory to find that a physicist who has won laurels as an investigator of purely theoretical questions, and whose generalisations have been so widely adopted, can seriously set about the examination of some of the problems which are involved in the commercial application of electrolysis. Too frequently do the exponents of pure science and of applied science meet on common ground, and it is not the fault of the technologists, who are always eager to profit by the "crumbs which fall from" the professorial "table." Knowledge is not dignified by conservation, but by dissemination. A scientific fact is not to be enshrouded in some obscure thesis, or buried in the brain of some worthy *magister* out of touch with economics, but to be trumpeted abroad, that "he who runs may read" and profit thereby. Human progress will gain in acceleration when there shall be no distinctions drawn between the so-called scientist and the technologist, and when both shall deem themselves most worthily employed in advancing the practical good of humanity.

Hitherto the prolific researches of Svanté Arrhenius have been chiefly concerned with the development of the dissociation hypothesis, hence an investigation by him upon the practical electrolysis of alkali salts at once arrests the attention. So far his results are more or less of a preliminary nature, and yet are pregnant with significance; hence, we believe that if he follow up this line of research, as there is every reason to believe that he intends to do, many of the uncertainties and disappointments which attend the commercial working of electrolytic processes will disappear, and an important sphere of operation will be opened up to electrical engineers. Commercial electrolysis is too promising a department of industry to be left to the empyricism of occasional patentees.

In the *Zeitschrift für Physikalische Chemie*, the usual organ in which the researches of Arrhenius are published, an account is given (*vide* Vol. xi., pp. 805—828) of some experiments recently carried out on the electrolysis of alkali salts. Arrhenius has shown that when the aqueous solution of an alkali salt is electrolysed with a mercury cathode, a considerable time elapses from the beginning of the electrolysis before hydrogen makes its appearance. This observation proves that hydrogen is not a primary product of the electrolysis, but results from the action of the water of the solution on the alkali amalgam primarily formed by the discharge of the positive ion, *i.e.*, the alkali metal. The time necessary for the appearance of the first bubble of hydrogen increases very slowly with diminution of current strength and (with a constant current of 0·05 ampère) increases with increase of concentration and lowering of temperature. It is practically constant for equivalent solutions of electrolytes with the same positive ion, but much larger for potassium salts than for lithium and sodium salts.

Arrhenius gave this phenomenon a theoretical investigation, and succeeded in demonstrating that the electromotive force necessary for electrolysis increases at the beginning with the quantity of electrolytic products already separated. In general, however, secondary reactions occur, which prevent the continued accumulation of these products if the primary process goes on very slowly; in this case the electromotive force necessary for electrolysis is almost exclusively conditioned by these secondary reactions. If the result of the secondary processes is the same as it is in the case of alkali salts, then the electromotive force necessary for the decomposition will also be the same, or nearly so. This conclusion is in accordance with the researches of Le Blanc (*vide Zeitschrift für Physikalische Chemie*, Vol. viii., p. 314), which therefore do not necessitate the assumption of a primary decomposition of the water.

The *Philosophical Magazine* ([5], xxxv., pp. 365—388) contains a paper by J. Shields, on "Hydrolysis in aqueous salt solutions." Here it is shown that a decinormal solution of sodium acetate is hydrolysed to the extent of 0·008 per cent. From this observation it is calculated that the electrical conductivity of pure water at 25° is $0{\cdot}56 \times 10^{-11}$; and this conductivity is greatly diminished when electrolytes are present. A salt of a strong acid and a strong base is hydrolysed to the extent of $1{\cdot}21 \times 10^{-4}$ per cent. in decinormal solution, the absolute quantity of the hydrolysed part being almost independent of the concentration. From the value of the electrolytic dissociation of pure water, it is possible to calculate the electromotive force which must be used to develop from water hydrogen and hydroxyl ions in a liquid already containing as many of these as are in normal solutions of strong acids or bases. The value calculated by Arrhenius is 0·81 volt, whilst the experimental value of Le Blanc is 0·76 volt.

As we have already remarked, these researches are of a preliminary character, but it is to be hoped that a physicist who has achieved such noteworthy results in the study of pure science will devote at least some of the resources of his knowledge to the extension of an investigation which, of necessity, will yield results of wide practical application. We shall await with interest Arrhenius's next paper on this subject.

COST OF ELECTRICAL ENERGY.

By W. H. BOOTH.

In Mr. Crompton's paper on the "Cost of Electrical Energy," a reference is made to the steam coals of the Midlands and of the North of England, which is very liable to lead the unwary astray; and a somewhat similar reference is made to Lancashire and similar class boilers that is equally misleading, and the latter reference is especially to be deprecated in that it condemns a system of working that has not only stood the test of time, but is also logically and scientifically correct, and in keeping with the principles that are followed out in steam using generally.

That a good reason is existent for criticising Mr. Crompton's *ex parte* statements may be inferred at the outset and perhaps accepted without much question, when it is considered that the standard 1,000 horse-power unit of the textile manufactory when built up of Lancashire boliers, flue economisers, and compound engines, contains between its limits such a combination of qualities as gives a result of one horse-power hour for $1\frac{3}{4}$ lb. of the above-named condemned coal. Such being the case, it is tolerably clear that one or both of Mr. Crompton's judgments must be seriously misleading. Taking the involved points seriatim, let us first apply ourselves to a consideration of the class of fuel stated by Mr. Crompton to be so poor in practical results that no modern furnace can utilise much more than a part of 50 to 70 per cent. of their constituents, which is the shortest form into which Mr. Crompton's statement can be compressed.

If this were correct, it would imply that in Lancashire, compound engines had a large efficiency indeed to secure so good a result as only $1\frac{3}{4}$ lb. fuel per H.P. hour from such poor coal.

Mr. Crompton plumps for the water-tube boiler. Now, the water-tube boiler cannot burn bituminous coal and evade the smoke act, but this is a poor reason for making the same statement of the Lancashire boiler. Hence Mr. Crompton plumps for Welsh smokeless, and advances the threadbare argument in favour of dear fuels, and shows moreover that he does not know much of the North, or he would scarcely advance the statement that nothing is said there about smoke. However, to return to the fuel.

The same fallacy to which Mr. Crompton extends his patronage was years ago held by the Admiralty and others, and Welsh coal was the only one allowed to be capable of even raising steam at all. In consequence of this the Association of Lancashire and Cheshire Coal Owners instituted a series of tests which were carried out in the years 1866, 1867, and 1868 at Wigan, and are known by the name of the Wigan coal trials. They were carried out with a view both to demonstrate the evaporative efficiency and the power of burning the coals smokelessly.

The boilers were of ordinary Lancashire and marine type, 7 feet in diameter, with furnace tubes of 2 feet 9 inches diameter, and the report on the trials may be almost con-

sidered as classic. They were carried out under the direct supervision of Sir William Fairbairn, and were the outcome of the Admiralty coal trials made by Sir H. De La Beche and Dr. Lyon Playfair, who very much under-rated the efficiency of all the bituminous coals, and placed the Welsh coals very high.

Alive to the errors in this report and feeling the effects of it, the Northumberland and Durham coal owners resolved to expose the worthlessness of the amateur tests of the Admiralty, and in 1855 the present Lord Armstrong, Dr. Richardson, and Mr. J. A. Longridge showed by a long series of experiments that not only could Newcastle coal evaporate more water than Welsh and more rapidly, but that this could be done smokelessly, and the Newcastle bituminous coals were thereupon placed upon the Admiralty list, leaving the equal and similar Lancashire, Yorkshire, and Midland coals in the cold. It was then decided to make the Wigan tests, and this was done by Dr. Richardson, of Newcastle, and the Manchester Steam Users Association. The marine boiler employed was a duplicate of that employed for testing purposes in H.M. dockyard Keyham.

The net result of the two years' tests showed an evaporation from 100° to 212° of 11·28 lbs. per pound of coal, a result fully equal to that obtained by the Welsh and Newcastle coals. The Admiralty officers sent down to inspect a repetition of the trials confirmed this, and their report was published, speaking strongly in favour of the South Lancashire and Cheshire coals.

It was afterwards decided to extend the tests to mill boilers. For this purpose two boilers were provided and a Green's economiser. No. 1 boiler, by Hick, Hargreaves, of Bolton, with steel tubes; No. 2, by Clayton's, of Preston, with iron tubes and a third water cone tube, was also put down. The feed was measured in a tank and the coal carefully weighed. We shall, in the future, refer in more detail to these tests which are evidently forgotten by some engineers, but for the present submit the following table verified, for the marine boiler, by the Admiralty officers as the mean of the different coals tested.

Character of trial.	Evaporation from 100° per pound of coal.	Cubic feet per hour evaporated from 100°.	Coal per square foot of grate per hour.	Smoke per hour.		
				Minutes very light.	Brown.	Black.
LANCASHIRE AND CHESHIRE COAL.						
Mean result of Association's tests ...	10·35	47·22	27	2·4	0	0
Ditto, Admiralty officers ...	10·68	48·30	27	1·1	0	0
Do., do, steam jet added	10·18	69·13	41	0·0	0	0
NORTH COUNTRY COAL.						
Hartley, tried at Keyham	10·71	43·0	...	3·4	0	0
Ditto, tried at Wigan ...	10·71	51·33	...	1·3	0	0
WELSH COAL.						
Tired at Keyham	10·14	38·60	...	3·1	0	0
„ „ Wigan ...	11·15	48·60	...	1·7	0	0
THE HAIGH YARD COAL (Lancashire)	11·24	47·38	...	0·5	0	0

A four hours' run at sea was equally conclusive as to both efficiency and smokelessness, and Messrs. Nicoll and Lynn, the Admiralty officers, declared the coals in every way fit for the navy.

Turning now to Mr. Crompton's remarks as to flue feed heaters, it may be said truly that to expose the products of combustion from a furnace to no greater cooling agency than the plates of a boiler whose temperature is between 370° and 400° is to neglect the great principle which makes compound working a success. Any boiler which exposes nascent flame to cooling influences is theoretically bad in principle, and the Lancashire boiler in this respect is like the water-tube boiler, at fault, but in a less degree. The water-tube boiler as almost invariably arranged, cannot, of course, burn bituminous fuels smokelessly. It could hardly do so were its water tubes replaced by bars of fire-brick, for the course of the air and gases is hopelessly wrong. The water-tube boiler was not made to burn bituminous fuel, and its friends very properly desire to have smokeless Welsh used instead, but it is hardly fair to ignore proved results with other appliances and other fuels in order to push a pet boiler. To say that the gases leave almost every other main class of boiler, except the Lancashire, at a temperature very slightly in excess of that of the steam, is at least to rate very low the steam engineering knowledge of the members of the Inst. E.E., and is scarcely a statement that could be made before the Inst. M.E. on a boiler night at least. No boiler, in which the circulation is as good as it is claimed to be in the water-tube boiler, could possibly effect this, and if Mr. Crompton is really of the opinion that his statement is correct, he must have been badly taken in by some very serious air leakage into the flues between the pyrometer and the boiler end. The division of the range of temperature of the working fluid of a heat engine is nearly or quite as important during that part of the cycle when heat is being added as it is during the period of fall, and no boiler can be economically worked without such division of duty. In the common form of economiser the hot gases are exposed to pipes of water which are gradually colder towards the chimney end by virtue of the construction of the whole, allowing a more rapid travel of the water in the pipes most exposed to heat. It is not a little strange to find the advocates of multi-cylinder engines condemning their own avowed principles; piling cylinder upon cylinder until a vertical engine resembles the steeple of a certain city church, and cutting down the boiler to such dimensions that its cooling and coolest surfaces can attack the burning gases before combustion of the hydrogens is fairly on the way. The principle of the miner's safety lamp has proved fairly effectual in checking the passage of flame between the two areas that are separated by the wire gauze. There are occasional passages of flame through an overcharged gauze, and occasionally flame may not be extinguished or cooled below the combustion point of carbon when it has to struggle between too many cold pipes, as it has to do in the water-tube boiler or the multi-tubular type. As regards the "usual" fusible plug there are few practical men who advocate this appliance which, already a fossil in idea, becomes too frequently a veritable fossil in actualilty from scale. But certainly the fusible plug cannot be termed a usual appliance. Neither can all forms of low water alarms be classed as troublesome. There is hardly a boiler in Lancashire or Yorkshire without the Hopkinson low water safety valve, and this appliance is one that gives very little trouble, and is very highly thought of. It has proved itself by many years of excellent work. A large cylinder boiler of Cornish, Lancashire, or externally fired type gives dry steam. It need not be asked why water-tube boilers have grown so very much larger in their upper storeys of late!

Finally, no greater mistake was ever made than Mr. Crompton makes when he declares that cheapnesss of fuel in the North has led to neglect of economies. The facts are the reverse. Any dealer in a high-class appliance, such as Green's "Economiser," will inform us that to sell one appliance where coal costs 20s. requires as much work as to sell a dozen within cartage distance of a coal pit. There are reasons for this. Cotton yarn is sold by the $\frac{1}{32}$nd part of a penny. One factory is as like another as are two peas, and coal consumption is reckoned out per pound of yarn produced. That place which lags behind in economy can be and is known at once, for, unlike an electric works, there can be no concealment of results behind a different class of conditions.

Apropos of the question of economisers, it may be added that no North-country engineer would dream of falling into the error of putting down boilers "big enough," whether of Lancashire or any other type, without the addition of the lower temperature absorber furnished by the flue feed heater.

Considering the enormous amount of experience in the country which was present to be drawn upon, there can be no excuse for any engineer having planned an electrical works out of line with precedents that had proved the soundness of their principles.

CORRESPONDENCE.

Muirhead v. Commercial Cable Company.

May I suggest that you in your leading article last week on the duplex case, and also your correspondent, Mr. Bailey, have apparently overlooked the fact that it is not so much the actual volume of the charge that is of importance as the *rate* of the charge.

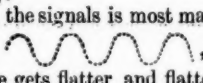
It is quite true that if you take a galvanometer of 5,000 ω, with a condenser in circuit, the throw on connecting a battery will be practically the same, whether you add another 5,000 ω to the circuit or not, *provided that the galvanometer is of comparatively slow periodicity, and the condenser of small capacity.*

The case is very different when dealing with delicate syphon recorders of very short periodicity, and the large condensers used in practice.

The following experiment illustrates this :—

I connected a condenser of 80 mf. capacity in series with an ordinary recorder of 500 ω (no recorders being as high as 5,000 ω), and charged it by connecting the circuit to two points in a resistance, shunting one cell so as to get the E.M.F. low enough to give a readable deflection. A series of signals were then sent by means of an auto-transmitter, so as to ensure their being all alike.

I enclose the tapes showing the records obtained with 0 extra resistance in the circuit, and with 50, 500, 2,000, 3,000, 5,000, and 10,000 ω, respectively.

You will see that the effect on the signals is most marked ; with 0 resistance the record is  , with intermediate resistances the curve gets flatter and flatter, till with 10,000 ω it is practically a straight line.

It is also surely as correct to say that a large condenser has 0 resistance as that it has ∞ resistance, since at the instant it is connected the potential across its terminals is 0, and it acts as though the battery were dead short-circuited ; and it is only after an appreciable time, when the condenser is fully charged, that it can be said to have an ∞ resistance.

In order that the two condenser arms of the bridge may have the same time constant, the products, $K_1 R_1$, $K_2 R_2$, must be equal, and therefore with the large condensers used on cable lines, the resistance of the rheostats must be low, whilst with small condensers the resistance can be altered by a large amount without greatly altering the rate of charge, and thus affecting the balance.

Probably the reason why the "practical experts" found the rheostat did not work as it was said to do was because they used small condensers instead of those having a capacity of 80—100 mf.

I should have expected that, in his long experience with duplex lines, Mr. Bailey would have found out practically that with large condensers the very smallest alteration in the rheostat affects the balance ; so much so that, in practice, adjustment is sometimes obtained by inserting a small piece of bare wire in the rheostat arm, and pulling it in or out of the terminal.

It is somewhat amusing that Mr. Bailey objects to a sliding rheostat on the score of the "great danger of an indifferent contact" at the apex of the bridge, where it cannot possibly affect the balance, since it only acts as a resistance in the battery circuit, and ignores the very real danger of a dirty or badly-fitting plug contact actually in the low resistance arm of the bridge.

A. H. Dykes.

Porous Lithanode.

In your last issue, on the last page, is given an abstract of patent No. 4,691, 1893, for "Improvements in the manufacture and production of elements for secondary batteries." This patent relates to the production of porous lithanode, by employing in the manufacture "an inert material or salt which will afterwards be removed or dissolved out."

To the casual reader, the publication of this abstract would naturally imply, at least *primâ facie*, two things, neither of which corresponds to actual fact, viz., that a patent has been *granted* for the process in question, and that this process is a novelty—an invention until recently unknown to the inventor of lithanode and to all those who, since the year 1885, have worked with him in the manufacture of this material.

Perhaps, through the intermediary of your columns, some of those gentlemen, *e.g.* W. H. Tasker, W. Kingsland, F. G. Howard, J. Appleton, A. E. Williamson, A. M. Keays, C. W. S. Crawley, &c., might be inclined to give their views as to the question of novelty, with special reference to a method for obtaining *surface porosity* practised in the time of the old Primary Battery Company, Limited.

In the meantime, will you allow me to state that the newly patented process is an old invention of mine which, as I find from my notes, I was practising in May, 1887, and which I have communicated to all those whom, from time to time, I have instructed in the manufacture of lithanode. Not that there was much *invention* in it ; I always considered it as an extension of the principle embodied in the patent No. 5,159, 1881, which I took out in conjunction with Mr. R. E. Crompton, and again in the patent No. 5,198, 1881, obtained by Mr. C. H. W. Biggs, Mr. W. W. Beaumont, and myself.

The salt mentioned in your abstract as "suitable," viz., the sulphate of magnesia, is one that was used by my directions to a considerable extent in the time of the late Mining and General Electric Lamp Company, Limited. But it is most unfortunate that it should now be given as an example of "an *inert* material or salt." As was well known to my assistant at the works of the company, and to those who used the plates manufactured with the crystals of sulphate of magnesia, this salt is decomposed by oxide of lead, with production of sulphate of the metal and small masses of magnesia, corresponding in form and size to the crystals used, distributed through the lithanode material. It was found that these particles of magnesia were by no means readily dissolved out, and that they were the cause of subsequent trouble in the form of efflorescence and "creeping," from which a lead accumulator should be quite free.

A salt much more "suitable," and one which would have the advantage of nearly coming within the present specification, was suggested to me by Mr. N. Story Maskelyne, F.R.S., in the course of a correspondence I had with that gentleman relative to the present subject. It is the decahydrated sulphate of soda—of course in very fine crystals. I have found, however, that the readiness with which this salt parts with its water of crystallisation is productive of inconvenience and uncertainty, and that, practically, the anhydrous sulphate of potash is preferable.

The old plan of producing only a *surface* porosity will probably be adopted by future manufacturers of lithanode, as it secures the advantage of high rate of discharge without an undue sacrifice of mechanical strength.

Desmond G. Fitz-Gerald.

Wanted!

With reference to your Note "Wanted," in this week's issue, I am afraid that I am the innocent cause of the Indian customer's trouble. Last year I exhibited a mock electrical machine at several concerts and entertainments named "The Electrolickedisonintophitsaphone" (ELECTRO-LICK-EDISON-INTO-PHITS-A-PHONE). The machine in question consisted of an oblong case covered with switches and instruments, and projecting from the front of this case were iron funnels. This case was stood over a trapdoor in the stage. A humorous dictation on the marvels of electricity was then given by a lecturer, who introduced the machine as the wonder, not only of this age but of all ages. Men and boys by turn got into the box, and on certain switches being turned on, almost any sound under the sun was mimicked. A great feature was a real German band. A final experiment was the turning on all the switches, when a fearful noise was heard like thunder, and the whole case flew into pieces and coloured fire and electric sparks burst forth, much to the horror of the discomfited lecturer, who rushed wildly from the platform.

If your enquirer is serious, I shall be very happy to supply any quantity.

F. Berlyn.

The Preliminary Examination in "Electric Lighting and Power Distribution."

The following is a copy of a letter addressed by me to Sir Philip Magnus, relating to the way in which candidates in the above examination are to have the results made known to them. This, and the reply thereto, will, I venture to think, be of interest to both teachers and students.

There is little doubt that the number of candidates will rapidly increase year by year, and it is to be hoped that at some future time the Institute authorities may see fit to modify their decision.

W. Perren Maycock, M.I.E.E.

May 9th, 1894.

[COPY.]

26, Stafford Road, Croydon,
May 5th, 1894.

Sir Philip Magnus,
Secretary Examinations Committee,
City and Guilds of London Institute,
South Kensington, S.W.

Dear Sir,—With reference to the newly instituted preliminary examination in "Electric Lighting and Power Distribution," may I ask in what manner the results will be made known to the students.

It has been a matter for surprise to others besides myself that your Committee should have decided not to give certificates for this examination; but if each successful candidate is to receive a note from the Institute recording his success, that would in a measure make up for the absence of a formal certificate.

From several years' workshop experience, I know there are very few electrical artisans proper who can hope to pass beyond the preliminary grade of this subject. To this numerous class of workers some duly authenticated acknowledgment of their having passed the examination in question would often prove of considerable value. If you will clear up this point, you will confer a great obligation on other teachers than myself, and on the students; to whom I beg leave to make known this correspondence through the medium of the ELECTRICAL REVIEW.

I am, Sir,
Your obedient Servant,
(Signed) W. PERREN MAYCOCK.

[COPY.]

City and Guilds of London Institute,
Examination Department,
Exhibition Road, London, S.W.,
May 7th, 1894.

Dear Sir,—I need scarely point out that the question of granting certificates on the result of the preliminary examination in electric lighting has been carefully considered by the several committees of this institute, and that the rule in the programme is the result of much deliberation. A list of candidates who may have passed that examination will be forwarded, as stated, to each centre at which they were examined, and it will be left to the local secretary to inform each separate candidate of his success or failure.

I am, Dear Sir,
Yours very truly,
(Signed) PHILIP MAGNUS.

W. P. Maycock, Esq.,
26, Stafford Road, Croydon.

Electricity Meters.

In your issue dated April 27th, you published a letter from Mr. Rankin Kennedy, in which he claims to have invented and patented the use of a transformer in connection with the shunt coil of a primary wattmeter.

Immediately this statement appeared, I wrote to this gentleman to ask for the number of his patent and the date; not having received any reply, I wrote the enclosed, which has been ignored also.

Under the circumstances I shall be much obliged if you will, by publishing the second letter, enable me to vindicate my historical accuracy at the expense of your correspondent's veracity.

R. P. Wilson.

[COPY.]

Rankin Kennedy, Esq.,
1, Clifton Villas, Camden Square, N.W. *May 3rd*, 1894.

Dear Sir,—I wrote to you last Friday asking you for further particulars of the British patent referred to in your letter to the ELECTRICAL REVIEW on the subject of primary wattmeters. If you cannot give me the date and number of the patent you referred to, I shall consider myself justified in assuming that no such patent exists except in your imagination. If there is such a patent there can be no possible objection to your giving me the number of it, and I have no doubt that you will see your way to do so without further delay.

Thanking you in anticipation,

I am, Dear Sir,
Yours faithfully,
R. WILSON.

Mr. R. P. Wilson has written me twice on this matter in a manner which I decline to answer privately. I have only to refer to Swinburne's book issued in 1888, pages 145 and 153, and page 371 ELECTRICAL REVIEW, April 22nd, 1887, for descriptions of my invention. I believe the patent was applied for in April, 1887, and its No. 6,201. Swinburne's publication proves that it was well known in 1888. This patent was abandoned, but the fact of my early discovery remains.

R. Kennedy.

LEGAL.

WILKINSON *v.* MEDICAL BATTERY COMPANY.

MR. JUSTICE VAUGHAN WILLIAMS, on Wednesday, had before him the adjourned application to allow the debenture holders' receiver for the Medical Battery Company to continue to sell the "Electropathic Belt." His Lordship had, when adjourning the summons, said he was loth to allow an officer of the court to continue to sell these goods by such methods as had previously been resorted to, in reply to which an assurance was given that the sale was being carried on without any false representation, and without any guarantee as to efficacy.

Mr. SWINFEN EADY, Q.C., said that prior to the winding-up order a debenture holder's action had been commenced in the Chancery Division, and a receiver had been appointed by Mr. Justice North. The terms of Mr. Justice North's order gave that receiver liberty to carry on the business in order to realise the stock-in-trade, which consisted of a large quantity of belts and appliances of various kinds. The cost of this stock had been £6,058. That was the estimated manufacturing price of the stock at the time of the stoppage of the company, and that was the property which formed the security of the debenture holders and creditors of the company. The Official Receiver estimated this stock to realise only £500 at break-up prices, but——

His LORDSHIP: That is to say that if they are not useful for the purpose of curing the sick they are no use at all?

Mr. EADY said he did not understand that it was that at all. If sold in bulk they would only fetch very little, but if sold gradually they would realise much more. Indeed, since Mr. Justice North's order, nearly £2,400 had been realised in sales of stock, and half the stock or a little more yet remained.

His LORDSHIP: Cannot you get the Royal College of Physicians or the Royal College of Surgeons to buy up the stock and distribute these things among the unfortunate people in the hospitals? (Laughter.)

Mr. EADY retorted that he was not aware that those institutions had any funds available for such purposes. The Royal College of Surgeons had not given evidence *en bloc*; but a reasonable number of them had been prepared to give evidence with regard to what they considered the value of the appliances. Ten witnesses were called out of the fifty whom the defence in the recent prosecution had in readiness, and one member of the College of Surgeons testified to the personal benefit he had derived from a belt.

His LORDSHIP: I tried a man at Bodmin in the spring for obtaining money by false pretences. The principal witness was a girl of nineteen. The prisoner had given her a charm, which consisted of a piece of black silk and the hair of a mole, I think, with an old sixpence sewn up in it. Counsel for the defence asked this girl whether before receiving the charm she had not had bad health. She said she had, and that now she was quite well, and that she could never be sufficiently grateful to the prisoner. I am happy to say the jury convicted him.

Mr. EADY said that no body of persons, especially of education and position, could have been got to give evidence in favour of the efficacy of that charm, so that the case was not on all fours with this belt. But he really was not concerned in its therapeutic value. At the same time he might mention that between 80,000 and 90,000 of the belts had been sold before the winding-up order, so that there were obviously many who believed in them.

Mr. JUSTICE WILLIAMS: I don't know that I have any right to express an opinion upon the belts, and I would rather not be asked to do so. Mr. Justice North made the order, and you are asking me to continue that order. Very well, for another two months.

INTERNATIONAL ELECTRIC SYNDICATE.

ON Wednesday last Mr. Justice Williams heard an application to remove the name of a shareholder from the list of the International Electric Syndicate, Limited. Mr. Eve said his client Mr. Jules Elder, asked to be struck off the list as holder of 200 shares. There were no creditors of the company and no assets. He understood the Official Receiver did not oppose this application. The company was ordered to be wound up on a contributories petition, and the question was whether this contributory could fix his client with liability to repay him. Counsel having explained the circumstances under which his client had been induced to accept shares, Mr. Justice Williams ordered the name to be removed.

Burton Electric Lighting.—Application is to be made to the Local Government Board for permission to borrow **£55,771**, chiefly for works of sewerage and the electric lighting operations.

BUSINESS NOTICES, &c.

St. Luke's Vestry and the Electric Light.—At a general meeting of the members of the St. Luke's Vestry, last week, the Parliamentary and Improvement Committee reported that they had considered the letters from the solicitors to the County of London and Brush Provincial Electric Lighting Company, Limited, forwarding copy of letter addressed to the Board of Trade relative to the financial position of the company, under the Electric Lighting Order obtained by the company in 1892, together with a letter from the Parliamentary Department, Board of Trade, asking the views of the Vestry upon the subject. After a long discussion the committee passed the following resolution:—"That the opinion of the solicitors to the Vestry be taken upon the question whether the order obtained by the company is now effective, in view of the fact that its terms have not been observed by the company, and to recommend the Vestry that, if necessary, notice be served upon the company to that effect, and intimating that the Vestry are not prepared to consent to the execution of any such works." The adoption of the report of the committee having been moved and seconded, the clerk read a letter from the solicitors to the Vestry, stating that as the company were now prepared to proceed with the works and make the necessary deposits, the Vestry would have to make out a very strong case before they would induce the Board of Trade to revoke the order. The Vestry ultimately passed a resolution disapproving of the plans submitted by the company.

Boese Accumulators.—The German Postmaster-General has just ordered 42 new mail coaches for the night express trains, which are to be electrically lighted, Boese accumulators being specified for that purpose. These accumulators have been in use for train lighting for the past 12 months, and the result has been so satisfactory that the German Post Office has now decided not only to adopt Boese accumulators for all new mail coaches, but also for the old ones now undergoing repair, thus replacing the use of gas. The Austrian state railway has consequent upon the German Government's experience also adopted these accumulators for train lighting, and we understand that the International Electric Company, of 55, Red Cross Street, who are the sole agents for the United Kingdom and the Colonies for these secondary batteries, have, within the last few months, had considerable sales for same.

Guildford Electric Lighting.—The Board of Trade has made, and issued, a provisional order with a view of the same being included in a Confirmation Bill about to be introduced into Parliament, authorising the Holloway Electricity Supply Company to supply electrical energy for public and private purposes within the borough of Guildford. The subjoined clause has been ordered by the Board of Trade to be included in the provisional order:—"The option of purchasing the undertaking under the provisions of Section 2 of the Electric Lighting Act, 1888, may be exercised by the local authority within six months after the expiration of 35 years after the commencement of the order, but if the said option is not exercised under the foregoing provision, the said section of the Electric Lighting Act, 1888, shall apply as if this section had not been included in this order."

Manchester Electric Lighting.—The Electric Lighting Committee of the Corporation of Manchester has recently placed with Messrs. Mather & Platt, Limited, an order for two Edison-Hopkinson dynamos each of 400 horse-power. The machines are to be similar to the two machines already supplied by this firm, having an output of 410 volts 590 ampères at a speed of 400 revolutions per minute, and are intended to work upon the feeders of the five-wire system. The committee have had so many applications for electric light that their present plant is fully loaded, and an extension is necessary before next season. These dynamos are to be worked by "Galloway" engines, similar to those already supplied by this firm.

Brush Electrical Engineering Company, Limited.—This company have lately published a neat and handy book of instructions for working the plant manufactured by them. The sections at present only cover their principal apparatus, but shortly the company hope to bring out a second edition in which will be included a variety of other articles of less importance. The book before us gives working instructions for Mordey-Victoria alternators and transformers, Brush-Vienna dynamos and motors, Victoria dynamos and motors, Brush dynamos and Brush-Geipel regulators, Brush arc lamps, steam boilers, &c., &c. The instructions throughout are nicely illustrated.

York and Electric Lighting.—The Streets and Buildings Committee of the York Corporation has considered the engineer's report with reference to the six selected tenders for the electric lighting of the city. The Committee resolved "That any proposal for the electric lighting of the city by a system involving the use of low tension currents only, be not entertained, and that the tenders reserved for further consideration be reduced to the four following, viz., the Brush Electrical Engineering Company, Limited, the Electrical Construction Company, Messrs. C. A. Parsons & Co., and Messrs. Siemens Brothers & Co., Limited."

Business Announcements.—We are informed that Mr. T. Collingwood has retired from the United Electric Wire Company, and is no longer, in any way, connected with the business of that firm, or of Messrs. F. H. Berry & Co., which will be carried on, as previously, under the management of Mr. F. H. Berry.

We hear that Mr. C. Ashmore Baker, A.I.E.E., has now established himself in his new premises at 28, John Street, Bedford Row, W.C., where he will continue to carry on his business as consulting electrical engineer.

Rosling & Matthews.—This firm is very busy, having a large quantity of orders for dynamos in hand. Many of these are for export, besides which they have two 30 K.W., one 24 K.W., and two 18 K.W. machines in hand for the trade, and two 17·5 K.W for the Theatre Royal, Bradford, many smaller ones. Last week the firm temporarily supplied an 8 H.P. (nominal) gas engine, and 7 K.W. dynamo to the Grand Theatre and Opera House, Leeds, for lighting the second act of "Utopia." After the performance on Friday night, Mr. Matthews exhibited to the theatre staff stage lighting effects, using the new arc lamp lately invented by Mr. Borland, of Leeds. We understand that Messrs. Rosling & Matthews are now abandoning nearly all installation work and confining themselves to building dynamos and motors for the trade.

Llandudno and the Electric Light.—Some gentlemen who had announced their intention of promoting an electric lighting company in Llandudno, have received an intimation from a committee of the Board of Commissioners to the effect that their proposals relative to forming the company have been declined. The report of this committee will come up for adoption at the next monthly meeting of the board, when there will doubtless be a good deal of discussion.

Nottingham Electric Light Station.—The erection of the massive cast-iron chimney cap at the above station has been entrusted to Mr. W. J. Furse, of that town, who has designed a special hoisting arrangement to ensure the safety of the undertaking. The diameter of the cap is 13 feet 6 inches, height 8 feet, and the weight over 9 tons. The shaft, from the designs of the Borough Engineer, will be 160 feet high, octagon in shape, and built from the inside.

Worcester Electric Lighting.—Enquiries being made as to when the Town Council will be ready to supply current, the Town Clerk recently replied that the Council hoped to be able to do so about the middle of October next. Mr. Preece has recommended the erection of 26 arc lamps for certain streets, also the acceptance of the tender of the Brush Electrical Engineering Company for the work, at £1,861.

Lists, &c.—We have received from Mr. W. Boby, manager of the Electric Couplings Syndicate, a circular describing and illustrating the "Secure" coupling for electric mains.

From Maschinenfabrik Oerlikon, we have received a catalogue which deals with alternate current machines (Oerlikon system) for single-phase and multiphase. The pamphlet is illustrated by a number of process blocks.

Hanley Electric Lighting.—The Electrical Engineer to the Town Council has been empowered to engage the following assistants as required during the next six months: Two electricians, two engine tenters, three stokers, one lamp trimmer, and two youths. The Borough Surveyor and the Electrical Engineer have been authorised to furnish the offices of the electricity works, and to obtain the stoking and other tools, &c., required.

Lithanode.—Owing to recent improvements made in the manufacture of lithanode, which have all tended to reduce the cost, the Lithanode and General Electric Company have decided to considerably reduce the price of their electric lighting and other lithanode cells.

Chelsea Supply Company's Sub-stations.—The following tenders were received for alterations to sub-station, Manor Street, for the Chelsea Electricity Supply Company, Limited:—T. D. Leng, £638; W. Stevens & Co., £613; J. Douglas, £515 10s. Under "Contracts Closed" we also refer to the Pavilion Road sub-station which is to be altered, Mr. J. Douglas having the contract.

Electric Light at Leeds.—The Great Synagogue in Belgrave Street, Leeds, is to be lighted by 77 incandescent lamps, the current for which will be taken from the House-to-House Company's mains. The interior work has been entrusted to Mr. T. Harding Churton, of Leeds.

Sell's Directory of Telegraphic Addresses. — In accordance with the intention which we announced a few weeks ago, Mr. H. Sell has just published, under date April, 1894, the first supplemental issue to the 1894 volume of his well-known directory of telegraphic addresses.

Poplar Electric Lighting.—The report of Mr. W. H. Preece, to which we have already referred in these columns, has been referred to the Works Committee of the Poplar Board of Works for consideration.

Theatre Lighting. — We understand that Messrs. Vaughan & Brown, Kirby Street, London, E.C., have been responsible for the lighting of the Empire Palace Theatre, Birmingham.

Club Lighting.—The premises of the Leeds and County Unionist Club, which were opened at the beginning of the week, are fitted throughout for the electric light by Messrs. Woodhouse and Rawson United, Bradford branch.

Electricians at Supper.—About fifty Edinburgh electricians held their annual supper last week, Mr. Cox-Walker being in the chair.

Change of Address.—The offices of the West Coast of America Telegraph Company were on Wednesday removed to 50 Old Broad Street, London, E.C.

Eastern Extension Australasia and China Telegraph.—The laying of the second section of the alternative Singapore-Hong-Kong cable—that between Labuan and Hong-Kong—has now been completed, and the line opened for traffic.

CONTRACTS OPEN AND CLOSED.

OPEN.

Southwark.—May 16th. The Commissioners for Public Baths and Wash-house for the parish of St. Saviour invite specifications and tenders for supplying and fixing an engine and dynamo at the Baths, Lavington Street, S.E., capable of producing current for 360 16-C.P. lamps, with all necessary exhaust and steam pipes and connections. Also for wiring the above building, and providing storage batteries, in accordance with the specification prepared by Mr. F. J. Smith, F.R.I.B.A., 17*b*, Great George Street, Westminster, from whom all information can be obtained, and at whose office the contract can be seen.

Tunbridge Wells.—June 6th. Tenders for supplying and laying the necessary plant and mains for the supply of electricity in the borough. For further particulars see advertisement pages.

CLOSED.

Derby.—Tenders were some time ago invited by the Estate Committee for wiring the police stations for electric lighting purposes, and the committee has recommended the Council to accept the tender of Mr. Fletcher, of Burnley, as follows: Police Station (Town Hall), £55 5s. 7d.; Lock-up, £33 14s. 11d.; Fire Station, £32 11s. 8d.; total £121 12s. 2d.

Derby.—The Town Council has accepted the tender of Messrs. Fletcher, of Burnley, for wiring the Town Hall and Babington Lane offices for electric lighting for the sum of £334.

London, S W.—For alterations to sub-station, Pavilion Road, for the Chelsea Electricity Supply Company, Limited:—

T. D. Long, Deptford	£474
W. Stevens & Co., Chelsea	438
J. Douglas, Chelsea (accepted)	391

Stafford.—The Town Council have accepted the tender of Messrs. Marshall, Sons & Co., Gainsborough, for three horizontal engines for electric lighting.

BOOKS RECEIVED.

The Steam Engine and other Heat Engines. By Prof. J. A. Ewing, M.A., B.Sc., &c., &c. Price 15s. Published by the University Press, Cambridge.

The Engineering Magazine for May, 1894.

FORTHCOMING EVENT.

Friday, May 18th, 1894, at 8 p.m.—Institution of Electrical Engineers, students meeting at 28, Victoria Street, S.W. Paper to be read, "Notes on Gas Engines," by P. W. Paget.

NOTES.

Electric Light at Belfast.—The Board of Guardians' gas bill amounting to a larger sum than that body are disposed to continue paying, a committee has been formed to inquire into the lighting of the buildings. Electric lighting has been suggested, and will be taken into account by the committee.

Rheumatism and Electrical Railways.—A leading article appeared in one of the medical papers last week on a subject which can be explained away in a few words. A tale is going the round of the press about a guard who had been for many years a martyr to rheumatism while in the service of one of the large companies, but who has never had a touch of the malady since he went to work on an electrical railway. We ourselves do not consider that electricity had anything whatever to do with the man being cured. The probability is that while engaged by his previous employers he was more exposed to the damp and cold than on the electric line, where the temperature is more equable, and where the guard is better protected from cold and wet.

India-Rubber Cables.—We understand that the tender of Hooper's Telegraph and India-Rubber Works, Limited, for manufacturing and laying about 170 knots of cable for the Cuba Submarine Telegraph Company, Limited, between Cienfuegos and Batabano has been accepted. It is interesting to record that this cable is to take the place of a gutta-percha one, which, owing to its exhibiting further indications of depreciation, has now been abandoned entirely. Mr. Jno. P. Hooper, in 1891, made and laid a cable similar to the new one, the manufacture and laying being completed without a hitch. We refer further to this matter in our leading columns.

Buda-Pesth General Electricity Joint Stock Company.—The electrical works erected by this company are supplying the city with electric energy, and in the brief time of their existence, the business has undergone so surprising a development that the works are already heavily overburdened. As we learn from the report of the directors, the works were originally planned for 12,000 lamps; now, after working for scarcely nine months, 16,760 lamps are already connected, and 36,860 more are applied for. This pleasing fact, which bears witness to the general approval of the company's system and to the satisfaction of the consuming public, renders an extension of the company's installation necessary. In view of this fact the company has entrusted their technical adviser, Prof. Dr. Kittler, with the elaboration of the plans. Since in accordance with the calculations before them the extension of the works and the increasing demands will require 1,000,000 marks, the directors proposed to increase the share capital from 3,000,000 to about 5,000,000 crowns, which was unanimously agreed to by the meeting. The installation, which was erected by the Electricity Joint Stock Company (formerly Schückert & Co.) on the "alternating current continuous current accumulator system," has acted since its opening in October, 1893, without drawbacks, and to the complete satisfaction of the public and the authorities, whilst the rival installation has often had irregularities in the supply of light, and the high tension alternating current has occasioned a number of accidents. We are indebted for this report to the courtesy of the general director.

Anonymous Journalism.—Mr. H. D. Traill, in his second Saturday afternoon lecture on "Literature and Journalism," referred to the much discussed and still debatable question of signed *versus* anonymous criticism. We are glad to find that such an authority should, from the fund of his experience, find cogent reasons for supporting the latter as being the lesser of two evils. Criticism, especially that often dubbed "destructive" by the unfortunate victim, is a thankless task, but one which those who—to use a term borrowed from Mr. Traill—"vend publicity" in return for a consideration dare not, and very seldom attempt to, shirk. The arguments *pro* are still stronger in the case of technical journalism than in that of the dailies, to which Mr. Traill expressly stated he limited his remarks. Those *con*, at the same time, lose much of their force. If the face value of a criticism is such that the objections and comments urged carry weight, it must be needless to show from whose pen they emanate. If, on the other hand, they do not convict, it is an unfairness to the individual or thing criticised that an all-powerful name should be brought against it, when, on the merits of the criticisms, they fail to make out a case. Mr. Traill pointed out very clearly how books of an inferior character should be dealt with: "Leave them alone; do not give them the benefit, even, of a condemnatory notice." We are afraid that were this principle carried out by the technical—and, more especially, the electrical—press, a great many three and sixpenny "popular" manuals would pass without comments on their birth. It is becoming increasingly difficult to ignore a mediocre production. On the one hand, the public want to know what the opinion of a competent reviewer is, and, on the other, the preface often states that the work is intended for a given class of readers. In this way, whatever Mr. Traill may hold regarding the duties of the daily Press, it is practically out of the question for technical works to be passed by in silence; nor, perhaps, would such a course be the most beneficial to the profession of engineering, or the public, for whose benefits books are prepared. The reasons are self-apparent why, in the majority of cases, this should be so.

Cambridge University Engineering Laboratory.—The new engineering laboratory will be opened on Tuesday, May 15th, at 3 p.m., by the Right Honourable Lord Kelvin, LL.D., P.R.S. The Vice-Chancellor of the University will preside.

The Hermite Electrical Sanitation Process.—The Portsmouth municipal authorities who sent a deputation to inspect the Hermite Electrical Sanitation Process at Worthing, propose to apply the system for the disinfection and deodorisation of the four miles of low level sewer running from the dockyard to the outfall at Cumberland Point. They have given instructions to Messrs. Paterson & Cooper to make a trial of the process with the portable plant lately used at Worthing, which is to be done at once, in order to ascertain the amount of plant necessary to attain the object in view.

The Post Office and Telephone Companies.—In the House of Commons last week, Sir J. Fergusson asked the Postmaster-General whether the agreement with the telephone companies had been completed or had made further progress, and what sum he proposed to expend out of loan on telephones in the present year. Mr. Labouchere asked whether the agreement had not been under discussion for two years, and whether the delay was not practically enabling the companies to secure a monopoly of the telephone business to the exclusion of those towns and municipalities who desired to obtain them. Mr. Arnold Morley said the provisional agreement was signed, he thought, in June, 1892. He did not think the delay was at all prejudicial to the action of municipalities. Considerable progress had been made with the agreement during the last few weeks, and the points of difference with the companies were now brought within a narrow compass. He hoped it would be possible to lay it on the table shortly. He preferred not to give his estimate of the cost till the agreement was completed.

Electric Traction and the Locomotive Acts.—A meeting of the Electrical Section of the London Chamber of Commerce, under the presidency of Major Flood Page, was held last Friday to consider the Locomotive Acts in relation to the electric traction industry. The secretary said that the question arose to some extent out of the publication of a letter in the *Times* some weeks ago stating that the Commissioner of Police held the opinion that electrically propelled vehicles came under the meaning of the Locomotive Acts. In consequence of that letter the secretary wrote to the Chief Commissioner asking whether the opinion attributed to him therein was correct, and after some delay the Commissioner replied on April 6th to the effect that he had been advised by his legal advisers that such vehicles as had come under the notice of the police, having electricity as the motive power, were locomotives within the meaning of the Acts 28 and 29 Victoria, cap. 83, sections 3 and 4; and 41 and 42 Victoria, cap. 77, section 29, and as locomotives came under the restriction clauses of those Acts. After some discussion, it was stated that the question really was whether an electric 'bus or cab is a locomotive under the meaning of the Act. Major Flood Page stated that when the Locomotive Acts were before Parliament in 1865, it was 14 years before any Committee of the House of Commons had ever sat upon electrical matters, therefore electrically propelled vehicles could not possibly have been in their minds when forming that Act. The meeting last Friday considered that as there will probably be great developments shortly in the application of electricity to street vehicles, some step should be taken at once, and after further discussion it was resolved that a communication be made to the Board of Trade claiming that electrical vehicles were outside the Acts, and in the event of the Board determining that they were included in the said Acts, to ask what steps they recommended to be taken, and whether they were prepared to render any assistance in the matter. Major Flood Page gave notice that at the next meeting of the section, which will probably be held about the end of the present month, the members would have to elect a new chairman, as the two years for which he had agreed to act in that position had expired. A short discussion was engaged in regarding the "rating of electrical works," and the question was adjourned for further consideration.

Fire in Dublin.—Henry Street, Dublin, was the scene of an extensive fire early last Friday morning. It is thought that the electric light wires supplying the building with current are responsible for the conflagration.

Wolverhampton Electric Lighting.—The Heath Town Local Board have resolved to consult an electrical engineer as to the advisability of applying for a provisional order, and as to the cost of introducing electric light into the district.

Electric Light in a City Church.—St. Anne and St. Agnes Church, Gresham Street, has been lighted by electricity; 31 16-C.P. incandescent lamps being fitted. Although the church was wired many months ago, the electric current was not turned on from the City Company's mains until last Sunday. Mr. W. H. Preece, C.B., prepared the specification, and Messrs. Sharp & Kent carried out the work.

Manchester Lighting.—The gas charges and the meter rentals occupied the attention of the City Council for some time last week. There is considerable dissatisfaction among the inhabitants regarding the charges imposed by the council. In reply to a question as to when the electric light was to be extended to the Stretford Road district, it was stated that if any of the leading shopkeepers and residents in that district would make a proposal to the Corporation, the Gas Committee would consider the propriety of supplying the district with electric light under their special powers.

The Insurance of Electric Lighting Works.—At a meeting of the Portsmouth Town Council last week, Ald. Ellis, chairman of the Electric Lighting Committee, stated that they had invited tenders for the insurance of the works at £30,000, and 15 companies considered the matter. They sent one inspector, and they were asked to pay 5s. per cent. He regarded this as monstrous, because it was humanly impossible for the place to catch fire. He had obtained an estimate for putting in four hydrants at £140 or £150, which would come to about two years' premium, and he therefore recommended that they should take their own risk. This course was sanctioned by the council.

A Long Electric Railroad. — A despatch, dated April 22nd, from Chicago to the *Financial News*, states that ground was to be broken for the Chicago and St. Louis Electric Railroad on May 1st. Twenty miles of the road from Alpine Heights into this city are to be built. Dr. Wellington Adams, of St. Louis, the promoter of the road, has been perfecting his plans and arranging to raise money. It is now said there is no longer any doubt about the road being pushed through to completion. The managers of the General Electric Company say that within eight months after receiving the order they can have all the electrical equipment for the entire line ready to deliver. It is said the company has no hesitancy in guaranteeing that it can build high-speed motors capable of travelling 100 miles an hour with perfect safety. Arrangements have been made to cross the Mississippi River at St. Louis on the Merchants' Bridge, and for terminal facilities in the new Union Station.

Exhibition at Bucharest, 1894.—The Department of Science and Art has received, through the Foreign Office, a despatch from Her Majesty's Charge d'Affaires at Bucharest, announcing that the Co-operators of Roumania propose to hold their fourth exhibition at Bucharest this year, to commence on August 26th, and to close on November 12th. In order to encourage foreign manufacturers to take part in the Exhibition, space is to be set apart for an International Section, in the hope that the relations between Roumania and the various countries with which she is in commercial intercourse may be strengthened thereby. The Exhibition is stated to be of a private character; but it will be under the patronage of their Royal Highnesses the Prince and Princess of Roumania, and, as on previous occasions, His Majesty, the King, has announced his intention of exhibiting agricultural and industrial products from the Royal and personal domains. Any information which may be required by intending exhibitors will be supplied on direct application to Monsieur Boutcoulescon, the President of the Exhibition 11bis Rue Clementei, Bucharest.

Electricity on Shipboard.—On board the *Undaunted*, cruiser, in Plymouth Sound, a trial of the electrical fittings was carried out last week, with satisfactory results.

Bury Electric Lighting.—Plan, &c., for the electric lighting scheme has been approved, and it has been resolved to apply for powers to borrow £25,000 for that purpose.

Charing Cross and Hampstead Electric Railway.—The Unopposed Bill Committee of the House of Commons on Tuesday passed the Bill promoted by the Charing Cross, Euston, and Hampstead Railway Company.

South Shields Electric Lighting.—At the Council meeting last week a report and estimate, made out by Mr. Jos. A. Jeckell, with regard to the electric lighting scheme here, were unanimously adopted, and permission granted to apply to the Local Government Board for £22,000 in accordance with his estimate. A deputation also was appointed to visit other central stations recently erected.

Appointments Vacant.—Sunderland Corporation are inviting applications up to May 12th for the post of superintendent electrical engineer during construction of station, and resident electrical engineer after completion. Salary, £200.

The Directors of the Salt Lake and Ogden Gas and Electric Light Company, Limited, are prepared to receive applications for the post of General Manager at their works in Salt Lake City, Utah.

Heilmann Electric Locomotive.—An interesting experiment in the adaptability of electric motor force to traction on railways was made, on Wednesday, on the Western Railway of France. The electric locomotive, invented by M. Heilmann, drew a special train from the St. Lazare terminus in Paris to Mantes (Seine et Oise) station, a distance of 33 miles, performing the journey in 55 minutes. The train was composed of five coaches and a dynamometric brake van, and at certain portions of the line a speed of 65 miles an hour was attained.

Bradford District Electric Lighting.—The Town Council the other day decided to circularise the residents of the districts of Frizinghall, Manningham and Heaton, which are not within the area of the gas supply of the Corporation, to ascertain their wishes with regard to supplying such districts with electricity; also to authorise the electrical engineer in the meantime to prepare an estimate of cost of suggested works; and also to circularise the residents in Great Horton Road and Otley Road, and places in the neighbourhood of those thoroughfares, to ascertain to what extent they would be prepared to take a supply of electricity in the event of the Corporation extending the electric cables to the said districts.

Lectures.—On the 29th inst. Mr. James Swinburne, M.I.C.E., M.I.E.E., will commence a course of lectures to the students of the Electrical Standardising, Testing and Training Institution, Faraday House, Charing Cross Road, on "Dynamo and Transformer Construction."

On Monday last, before the Society of Chemical Industry, a paper was read by Mr. Claude Vanten on "The Commercial Electrolysis of Fused Salts."

Mr. S. A. Notcutt, L.L.M., B.A., B.Sc., on Wednesday last week, read a paper on "Electric Waves and the Ether Theory of Electricity," illustrated by numerous experiments, before the Ipswich Scientific Society, of which he is President.

Calcutta Electric Lighting.—According to an Indian exchange, the question of introducing a supply of electricity into Calcutta is in abeyance, owing to the intention of legislating on the subject before granting licences to any syndicate or promoters. It is some years since more than one firm entered the field and offered to put Calcutta on a par with other prominent cities as regards electric lighting, but, for want of sanction, nothing whatever has been done up to the present, and it has to be recorded, says our contemporary, "with no small regret in this case, as has been done in many others, that whereas private enterprise was ready to push forward, the official brake has brought things to a standstill."

London County Council and Technical Education.—We are informed by the County Council that, with a view to promoting a better understanding of the needs and desires of the various trades in the matter of technical education, it is proposed to hold, during the months of June and July next, a series of public conferences between the representatives of the principal London industries. It is hoped, by a free and practical discussion among those actually concerned in industry, to elicit useful information as to what kind of technical education is required in each case, in what way the existing provision is defective, how it can be rendered more efficient, and what steps can be taken to bring it to the notice of the young workman or the apprentice. Both employers and employed are invited. The first meeting will be devoted to the building and furniture trades, and the three subsequent meetings, following at fortnightly intervals, will deal respectively with the engineering, shipbuilding, and metal trades, the book, paper and printing trades, and the clothing, leather and miscellaneous trades.

NEW COMPANY REGISTERED.

"Harp" Arc Lamp Syndicate, Limited (41,057).—This company was registered on the 1st inst. with a capital of £5,000 in £1 shares, to enter into an agreement with Mr. Wolstan Trubshawe; and to carry on the business of electricians, mechanical engineers, and suppliers of electricity for the purposes of light, heat, motive power, or otherwise. The subscribers (with one share each) are:—A. Chester, 4, Kingsley Mansions, West Kensington, electrical engineer; W. Trubshawe, 6, St. Benet Place, E.C., merchant; J. J. Rathbone, 78, Loftus Road, W., electrical engineer; D. Fowler, 6, East India Avenue, E.C., merchant; F. O'S. B. Reade, 83, Warwick Road, S.W., gentleman; T. W. Bredgford, 2, Draper's Gardens, E.C., gentleman; G. F. Garry, 1, Westfield Road, Surbiton, gentleman. The first directors are A. C. V. Trubshawe, F. O'S. B. Reade; remuneration to be fixed in general meeting. Registered by E. F. Turner, 101, Leadenhall Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Keswick Electric Light Company, Limited (28,820).—The annual return of this company was filed on the 27th ult. It shows that out of a nominal capital of £5,000, in £1 shares, 3,420 shares have been taken up, and that the full amount has been paid.

New Telephone Company, Limited (20,483).—This company's last yearly return, made up as far as January, 1894, shows that out of a nominal capital of £750,000 in 74,700 £10 and 3,000 £1 shares, 74,695 of the former and the whole of the latter have been taken up. There has been £10 called on each of 5,103 shares, £4 on 69,097, and £1 on 3,000. The total sum received is £330,358; £5,000 has been agreed to be considered as paid; £60 is outstanding; and £10 has been forfeited on five shares.

Northern Electric Wire and Cable Manufacturing Company, Limited (29,199).—This company's yearly return, filed on April 28th last, shows that out of a nominal capital of £20,000 in 660 fully paid and 3,340 ordinary shares, all of £5 each, one fully paid and 2,267 ordinary shares have been taken up, with a sum of £2 10s. called on each of the latter. The total received is £5,665; £3,300 has been agreed to be considered as paid; and £2 10s. is outstanding.

National Electric Supply Company, Limited (29,992).—This company's annual return, filed on the 17th of last March, shows that out of a nominal capital of £100,000 in 100 founders and 19,900 ordinary shares, all of £5 each, the whole of the founders and 10,505 of the ordinary shares have been taken up, and that the full amount has been called on all. A sum of £53,010 has been received; and £15 is in arrear.

CITY NOTES.

The London Electric Supply Corporation, Limited.

The report of this company is full of interest, and though, until we receive figures which will enable us to get out the working cost, justice cannot be done it, we give some of the directors' remarks.

During the short time the new transformers have been in use their greater efficiency has sensibly decreased the loss of current. When the whole of them are installed, a considerable advantage will arise from the increase in the proportion of saleable current to current generated. The other important new works described in the engineer's report have proved beneficial, and have materially increased the efficiency of the system of supply.

The increase in the number of lights during the year is stated in the engineer's report, and amounts to about 34 per cent. But for the general depression of trade, the rate of increase, which was most marked in the first half of the year, would doubtless have been greater.

The result of the year's working shows an improvement on previous years, the revenue account showing a small balance to the good, as against a loss of £3,914 9s. 7d. last year; and this notwithstanding the reduction of the standard charge to 6d. per unit, and the severe and continuing competition in the best districts of the company's area of supply.

In view of the growing increase in the use of electricity, and of ensuring uninterrupted continuity of supply to consumers, the board recommend that a new generating unit of 1,250 H.P. be provided as speedily as may be. This, with the necessary apparatus for connecting new customers will, however, involve a further extension and expenditure of capital.

We extract the following from Mr. D'Alton's report:—

"We commenced the year with a connection of 46,197 lights; at the end of the year the number had increased to 61,924. But for the commercial depression and other disturbing causes in the latter half of year, the increase would probably have been greater.

"Towards the end of the year a new 300 H.P. dynamo was brought into use. This will prove a great advantage in enabling us to deal with our daylight load without starting the larger machines, and in this way a marked economy will be effected.

"The 10,000-volt trunk mains from Deptford to London, originally fixed to the parapet of the South Eastern Railway, were removed and laid underground with perfect success during the summer, and without any interference with the continuity of supply. By this important work we are now protected from the accidents from which we suffered so seriously in the past; whilst the annual charges will be considerably decreased, owing to the reduction in the cost of maintenance, and the rental of wayleaves on the railway.

"The distributing mains have been carried into the parish of Chelsea, and further extensions have been made in the parishes of St. George's, Hanover Square; St. James; St. Martin's; St. George-the-Martyr's; St. Margaret and St. John; St. Saviour's; St. Olave's and Newington; amounting in all to 2½ miles, bringing the total length of distributing mains laid to 38 miles. All the company's mains have worked satisfactorily during the year, and the charges for repairs and maintenance have been lessened.

"A filtering plant, capable of dealing with 100,000 gallons of water per day, has recently been erected at Deptford, by which we are now able to use the river water for the boiler supply, and thus to dispense with a great portion of the supply hitherto derived from the Kent Waterworks Company. This will result in a saving of from £400 to £500 per annum under present conditions.

"New house transformers, amounting to 2,442 H.P., were purchased last year; of these, 1,477 H.P. are now in use on the circuits, leaving in stock 965 H.P., which are being put into use as speedily as possible. Owing to the delay of the manufacturers in making delivery, it was not until the last month of the year that this work could be commenced, but, from the observations I have taken up to the present time, I am able to say that this change will have good economical results. To replace the whole of the old type transformers now in use, a further 1,045 H.P. of the new type will be required.

"The generating and distributing plant is in good order, and is working to my entire satisfaction."

The total receipts for the year amounted to £25,316, the expenses reaching this figure less £172.

Submarine Cables Trust.

The 23rd ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held on Thursday last week at Winchester House, the Marquis of Tweeddale presiding.

The Chairman said the revenue for the past 12 months amounted to £22,593, as compared with £23,102 in the preceding year, showing a decrease of £509. This decrease was due to their having received a smaller dividend during the year from their investment in the Anglo-American Telegraph Company. He regretted to say that there was no visible improvement in the traffic on the Atlantic, and he feared that their income from that source was likely to suffer for some time to come. The expenditure for the year totalled £1,301, as against £1,627, showing a decrease of £326. This diminution was mainly owing to a reduction in the number of the trustees, consequent upon the lamented death of their late colleague, Sir J. Anderson. The cost of administering the trust was £698 under the amount provided by the trust deed. The revenue during the past year was sufficient to meet two coupons of £3 each, and to pay an additional 5s. on the overdue coupon. There still remained £1 5s. in arrear, which they hoped to pay in about July next. Although the traffic in the Atlantic was very low at present, they must hope that with a return of business it would improve, in which case their income would be in a very satisfactory condition. In conclusion, the chairman moved the adoption of the report.

Mr. J. D. Pender seconded the resolution, which was carried unanimously.

West India and Panama Telegraph Company, Limited.

The thirty-fourth ordinary general meeting of this company was held last Wednesday at Winchester House, Mr. C. W. Earle presiding.

The Chairman said the report, of which he moved the adoption, dealt with an uneventful period of the company's history. In the past six months they had received £4,093 less than in the corresponding period of the previous year, while the expenses were £2,553 less, the net result being that they were £1,540 worse off than at the end of the corresponding period. Under these circumstances it might naturally be asked why they were able to pay an extra 3d. dividend as compared with this time last year, when they paid 6d. per share. That was to be explained by the provisions they were enabled to make during the first six months of 1893, when they had a windfall of some £2,000, owing to the interruption for some seven weeks of the competing French cable between Hayti and Cuba, the consequence of which was that all the international traffic passed over this company's line between Martinique and Cuba. That enabled them to contribute £3,000 to the reserve fund, and carry forward about £4,000.

Mr. Gerald W. Balfour, M.P., seconded the resolution, which was carried unanimously.

Western and Brazilian Telegraph Company, Limited.

The report of the directors for the half year ended December 31st, 1893, states that the total earnings amount to £80,338 18s. 3d. as against £86,954 11s. 2d., showing a decrease of £6,615 12s. 11d. compared with the half-year to December 31st, 1892.

The working expenses amount to £35,592 8s. 10d., as against £37,165 11s. 5d., a decrease of £1,573 2s. 7d. Including the amount brought forward from June 30th, 1893 (£7,679 4s. 7d.), and the dividend received upon the shares held in the Platino Company, the balance to the credit of the revenue account is £61,659 9s., from which has been deducted £12,027 for debenture interest, and £7,073 for the debenture redemption fund, leaving £42,559 9s., of which £5,000 has been placed to the reserve fund.

The directors now recommend the payment of a dividend of 7s. 6d. per share (free of income tax) on the ordinary shares, being a dividend of £2 10s. per cent. for the year, leaving a balance of £1,045 6s. 6d. to be carried forward. In the case of shares which have been divided into preferred and deferred, the 7s. 6d. per share now recommended will be payable to the preferred shareholders, making up the full dividend of £5 per cent. on the preferred shares for the year 1893.

The fourth annual drawing of the "A" and "B" debentures took place in January, and £14,200 was drawn, and has since been paid off at par. The Pacific and European Company's land line connecting Buenos Ayres with Valparaiso was opened for traffic in March.

Stock Exchange Notices.—The Stock Exchange Committee have ordered the following to be quoted in the official list:—Telegraph Construction and Maintenance Company, Limited, £150,000 5 per cent. debentures, Nos. 1 to 1,500.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending May 6th, 1894, amounted to £886; week ending May 7th, 1893, £793; increase, £93; total receipts for half-year, 1894, £16,400; corresponding period, 1893, £16,154; increase, £246.

The Great Northern Telegraph Company. The traffic receipts in April, 1894, were £20,000; January 1st to April 20th, 1894, £83,000; corresponding months, 1893, £84,000; corresponding month, 1892, £82,800.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 4th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,294.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, May 2nd.	Closing Quotation, May 8 h.	Business done during week ended May 8th, 1894. Highest.	Lowest.
184,500l	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	101 —104	101 —104	...	...
1,134,640l	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	43 — 45	43 — 45	...	...
2,932,680l	Do. do. 6 % Pref.	Stock	£5 5s.	£5 10s.	£5 2s.	80½— 81½	80½— 81½	81⅛	80½
2,932,680l	Do. do. Defd.	Stock	...	...	...	7¾— 8¼	7½— 8	7¾	7½
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6½ % §	6½ % §	12 — 12½	12 — 12½	12¼	12 3/16
18,700l	Do. do. 5 % Bonds	100	...	...	...	100 —103	100 —103	...	...
75,000l	Do. do. 5 %, repayable June 1906	100	...	...	...	108 —112	108 —112	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10% ‖ §	... §	1½— 2½	1½— 2½	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	146 —150	140 —145	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3½ % §	2 % §	... §	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13	12 — 13	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	18 — 19	18 — 19	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½%	4 %	4 %	2¾ — 3¼	2¾— 3¼	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	...	8¾— 9¼	8¾— 9¼	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	3½% §	...	9½— 9¾	9½— 10	9⅝	9 9/16
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	14⅞— 15⅛	14⅞— 15⅛	15 1/16	14⅞
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	16 — 16½	16 — 16½	16 1/16	...
105,900l	Do. 5 % Debs., repay. August, 1899	100	...	...	...	107 —110	107 —110	...	...
1,294,100l	Do. 4 % Mort. Deb.	Stock	...	...	...	115 —118	114 —117	115¾	114½
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	15⅜— 15⅝	15⅜— 15⅝	15⅝	15½
62,700l	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	103 —106	103 —106	105¾	...
222,800l	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106	103 —106	...	...
320,000l	Do. 4 % Deb. Stock	Stock	...	...	...	114 —117	114 —117	...	...
95,100l	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	103 —106	103 —106	...	...
129,100l	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106	103 —106	...	...
300,000l	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	104 —107	104 —107	...	...
200,000l	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	105 —108%xd	105 —108%	106½	...
180,227	Globe Telegraph and Trust, Ltd.	10	5¼% §	4¾% §	4⅝% §	8¾— 9	8¾— 9	9	8 13/16
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	15⅛— 15⅜	15⅛— 15⅜	15⅜	15 5/16
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅗% §	8⅗% §	8⅗%	21¼— 21¾xd	21¼— 21¾xd	21 5/16	21¼
200,000l	Do. do. do. 5 % Debs.	100	...	...	...	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	45 — 47	45 — 47	...	...
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	4 — 6	4 — 6	...	...
100,000l	Do. do. 6 % Debs.	100	...	...	...	106 —109	106 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	½— 1½	½— 1½	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1 — 2	1 — 2	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	...	4¾— 5	4¾— 5	4 15/16	4 13/16
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	15 — 16	15 — 16	15½	15
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	14½— 15½	14½— 15½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5⅜— 5⅝	5⅜— 5⅝	5⅝	5½
925,017l	Do. 4½ % Deb. Stock Prov. Certs. ...	...	...	...	...	115 —117	114 —116	115⅞	115¼
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	⅜— ¾	⅜— ¾	...	...
100,000l	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	102 —105	102 —105	...	...
11,839	Reuter's Ltd.	8	5 %	5 %	...	5½— 6½	5½— 6½	...	...
3,381	Submarine Cables Trust	Cert	...	...	...	111 —116	111 —116	...	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1½— 2	1½— 2	...	...
146,370l	Do. do. 5 % Debs.	Stock	...	...	...	90 —100	90 —100	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	...	3 — 5	3 — 5	...	...
‖249,900l	Do. do. do. 5 % Debs.	100	...	...	...	100 —103	100 —103	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	2½— 3	2½— 3	...	...
150,000l	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	105 —109	105 —109	...	...
64,242	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	...	7¼— 7⅜	7½— 8	7⅜	7¼
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6 — 6½	6½— 7	6 13/16	6⅝
33,129	Do. do. do. 5 % Def. ...	7½	3 %	...	...	2 — 2½	2 — 2½	...	...
178,200l	Do. do. do. 6 % Debs. "A," 1910 ...	100	...	...	...	106 —109	106 —109	...	...
222,700l	Do. 6 % Mort. Debs, series "B," red. Feb. 1910	100	...	...	...	106 —109	106 —109	...	...
88,321	West India and Panama Teleg., Ltd.	10	1/16%	1/16%	...	1¼— 1⅜	1⅛— 1⅜	1¼	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10½— 11	10½— 11	10¾	10 11/16
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	...	..	9 — 10	9 — 10	...	...
80,000l	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	109 —112	109 —112	...	...
$1,214,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	110 —115 xd	110 —115 xd	...	...
169,000l	Do. do. 6 % Ster. Bonds.	100	...	...	...	100 —104	100 —104	...	...

ELECTRICITY SUPPLY COMPANIES.

20,510	Charing Cross and Strand Electy. Supply, 1 to 6, 215 to 718, and 10,001 to 30,000	5	...	5 %	4½%	4 — 5	4½— 5½	5⅛	4¾
40,000	Cityof London Elec. Lightg. Co., Ltd., Ord. 40,000—180,000	10	...	...	...	12 — 13	12 — 13	...	...
20,000	Do. do. 6 % Cum. Pref., 1 to 20,000	10	...	6 %	6 %	13¼— 13¾	13½— 14	13¾	13½
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) £75 paid	...	...	...	...	82 — 85	83 — 85	84¾	84⅜
19,900	*Electy. Supply Co. of Spain, 101 to 20,000...	5	...	...	...	... ...	... ...	...	...
5,523	†Liverpool Electric Supply, £4 10s. paid	5	...	...	...	5⅞— 6⅛	5⅞— 6⅛	...	...
39,477	Do. do.	5	4½%	5 %	5 %	6½— 6⅝	6½— 6⅝	6½	...
49,900	*Metropolitan Electric Supply, Ltd., 6,101 to 50,000 ...	10	1 %	2 %	...	7 — 7½xd	7½— 8 xd	7¾	7⅜
100,000l	Do. 5% Deb., 1 to 10,000 in bonds of £10, £20, £40	...	...	...	...	106 — 109	108 —111	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	4¼— 5½	4½— 5½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7½%	4½%	6¾— 7½	6¾— 7¼	...	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8 — 8½	8 — 8½	8 5/16	8
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	...	3½%	4 %	5¾— 6¼	5¾— 6¼	...	...

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ¶ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, May 2nd.	Closing Quotation, May 8th.	Business done during week ended May 8th, 1894. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2⅝— 3	2⅝— 3	2 1/16	2 1/16
90,000	Do. do. Non-cum. 6 % Pref, 1 to 90,000	2	...	6 % §	6 % §	2⅛— 2⅜	2⅛— 2⅜	2⅛	2 1/16
125,000£	Do. do. 4½ % Deb.	Stock	...	...	...	108 —111	107 —110	...	...
630,000£	City and South London Railway	Stock	...	⅝%	⅝%	27 — 32	28 — 30	29⅛	28½
20,000	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 20,000	5	7 % §	7 % §	7 % §	3¼— 3⅜	3¼— 3⅜	...	...
50,000£	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	95 —100	95 —100	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	½— 1	¼— ⅜	⅜	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1¼— 1⅜	1¼— 1⅜	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd, 1 to 66,750 ...	2	*nil*	*nil*	*nil*	⅛— ¼	⅛— ¼	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	½— ¾	½— ¾	...	...
67,385	Elmore's Wire Mfg., Ltd., 1 to 67,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	½— ¾	¾— 1	⅞	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½— 1½	½— 1½	...	...
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½— 7½	6½— 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd, Ord.	10	...	...	...	6 — 7	6 — 7	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	23 — 24	23 — 24	24	23
200,000	Do. do. do. 4½ % Deb., 1896	100	...	...	...	102 —104	102 —104	103	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	7⅛— 7⅜	7 — 7⅛	7⅛	...
6,295	† Do. do. Pref., £8 paid	10	...	...	...	12⅝— 13⅛	12⅝— 13⅛	13	...
78,949	Swan United Electric Light, Ltd., £3½ paid	5	11 % §	10 % §	7½% §	2 — 2⅛	2 — 2⅛	2⅛	...
37,950	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	39 — 41	39 — 41	40	39¾
150,000£	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	... ...	... ...	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

CROMPTON & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅜.

Electric Construction Corporation, 6 % Debentures, 87—92.

Electric and General Investment, shares of £5 (£1 paid), 1⅞—2¼.

Electricity Supply Corporation, Ordinary of £5, 5—5¼.

House-to-House Company (£5 paid), 1—1½.

Do. do. 7 % Preference, of £5, 5¼—5½.

Do. do. 6 % Debentures of £100, 101—103.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 4⅜—5¼; 1st Preference Cumulative 6 %, £5 (fully paid), 6¼—6⅜.

Liverpool Electric Supply, £5 (fully paid), 6½—6⅝.

Do. do. £3 10s. paid, 4½—4⅝.

London Electric Supply Corporation, £5 Ordinary, ⅞—1⅛.

Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 101—103.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4¼—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

REVIEW.

The Eight Hours Day in British Engineering Industries: an Examination and Criticism of Recent Experiments. By J. STEPHEN JEANS. 29, Great George Street, Westminster, S.W.

This is a sixty page pamphlet dealing with a great practical problem in detail with much ability. Reports have been obtained from many of the great employers in the engineering trades, all of them adverse to the statements put forward by the advocates of the eight hours day.

That the production has been, on the whole, maintained, during the experiment at Salford and at Sunderland, is attributed to increased exertion not likely to be permanent. The loss involved by the eight hours day for the engineering firms of England and Wales is estimated to be, if adopted, certainly more than four millions sterling per annum, even if they continue to secure orders, but, as the increase of cost of production will have the effect of driving away trade from the country, the penalty will recoil on the heads of the workmen in reduced employment and probably lower wages. The workmen of this country are handicapping themselves in the race against their continental rivals. By reducing their working hours and exacting higher wages, they are unwisely sacrificing more than all the natural advantages hitherto enjoyed by Britain. In shipbuilding, the average English wage is nearly one-half more than the German, and there is a further 15 per cent. against England in consequence of the longer hours worked in Germany. Cheap and ample capital, efficient skilled labour, and low-priced materials, although they have been our heritage, are not necessarily our monopoly.

The machines cannot be made to work faster merely because the workmen demand a shorter day, but the men must work under greater pressure all the time if the short day is to remain. This, it is shown, is likely to be hard upon men who are already past the prime of life. If an accelerated pace is to be one of the demands of the future, many thousands of the men, who have hitherto been able to exercise their calling satisfactorily under the old system, will have to drop out of the race, in order to make way for younger and more vigorous men under the "driving" system that has to take its place. Is it to be maintained that this is a change for the better?

The author takes the same view as we have already expressed of the amount of energy required to start a machine, and to watch and work it for a couple of hours before breakfast.

We think this pamphlet well deserving of careful consideration by employers and workmen. It is not a restricted production that will ever improve trade. If every workman in England, instead of bridling his energy and shortening his hours of labour, both to a minimum, would adopt the following old advice as his formula of conduct "Give, and it shall be given unto you; good measure, pressed down, and shaken together, and running over, shall men give into your bosom, for with the same measure that ye mete withal it shall be measured to you again," we would soon see a revival in trade all round. Upon the whole, as applied to any community, this is bound to be true, not because the words are sacred, but because they are common-sense. Accumulated wealth autocratically controlled is alone capable of keeping the industrial world in profitable employment, and without such accumulations trade must be in a state of stagnation. So necessary for the welfare of the workmen are these accumulations that, if they understood their own interest aright, they would make it their first anxiety to be sure that their employer is making money. The beginning of every period of bad trade has always been that some employer has been paying his workmen and leaving himself without remuneration.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

COST OF ELECTRICAL ENERGY. By R. E. CROMPTON, M.Inst.C.E. Vice-President. (Read Thursday, April 26th, 1894.)

(*Concluded from page* 531.)

Another point which is receiving the attention of all of us is the extended application of condensing plant.

In situations where condensing water is available this problem presents no difficulty, but in a large number of cases condensing water is not available; and of late years—in fact, dating from the time of my 1891 paper—a number of proposals have been made to introduce what are called evaporative or surface condensers, which may be described as consisting of a very extended surface of tubes through which the steam passes, the tubes being cooled externally partly by an air-fan blast, and partly by a limited supply of water trickling on to the outside of them. Of course, so long as the amount of water used is equal to the feed water used, there would be no advantage in using such a condenser, other than that the steam consumption may possibly be economised, especially at times of light load, so that the steam that is required to pass through the condenser would be proportionately reduced; but Mr. Ledward and several other gentlemen who have paid attention to this subject are confident that they will be able to eventually reduce the cooling water required to two-thirds of that of the ordinary feed water; and if this is the case, it will result in a very great advantage, not only in removing the nuisance—which some people insist is a real nuisance—of the steam issuing from the chimneys of the various supply works, but the difficulties with the boilers will be also greatly diminished. But it must be recollected that this use of condensing water entails the working out of several very difficult problems connected with the thorough filtering out of the oil contained in the exhaust steam before it is allowed to re-enter the boilers. The united opinion of nearly all boiler engineers and inspectors is to the effect that if the water contains the smallest percentage of carbonate of lime the entry of even minute quantities of oil into the boiler is likely to have disastrous effects. The oil forms with the carbonate of lime a covering to the flues and tubes of a highly non-conducting nature, which allows the iron or steel plates or tubes to be greatly over-heated, and great damage is thus done; so that most boiler insurance companies absolutely forbid the returning of condensed water to the boiler unless it has previously passed through a purifying apparatus which absolutely frees it from the oil.

I have briefly mentioned how very considerably the wasteful nature of the steam pumps that are at present available for boiler feed pumps affects the total economy of the works. For some time past at Chelmsford I have attempted to deal with this difficulty by supplying my boilers with feed pumps electrically driven; and although these electrically driven feed pumps are by no means as efficient as I hope to make them in the future, yet in their present state their use shows a marked economy over the Worthington or other direct-acting pumps that were previously employed. The electrically driven pumps use the energy from the main switchboard, which is generated in an economical manner; whereas the direct-driven pumps are driven not so much by steam as by water condensed in their steam pipes. I have over and over again called the attention of pump makers to the great want there is of a more economical steam pump than is at present in the market; but there appears to be a difficulty in dealing with the question, I believe chiefly owing to the intermittent way in which these feed pumps are worked, so that between periods of working their supply steam pipes get comparatively cooled.

I have spoken of the difficulty I have met with in obtaining trustworthy figures as regards water consumption. This is mainly due to the fact that a thoroughly trustworthy water meter is not an easy article to meet with. In order that such a water meter may accurately record the water fed into the boiler, it ought to be placed between the feed water heater and the boiler, so that any leakages that may occur at the pumps themselves, or in the lines of pipes, or in the feed water heater itself, may not affect the question of boiler evaporation. This necessarily means that such a water meter must pass hot water. For several years past I have been using Schönheyder's meter in this position, with fairly satisfactory results, but in its present state it leaves much to be desired. The pins wear to such an extent that in our Chelmsford case we find it necessary to take the meter out and replace the pins and recalibrate it once every three or four months. The calibration of such a meter is not a difficult matter if the feed water in any part of its course passes through a rectangular tank, the cubic contents of which can be readily measured, and the water contained marked for each inch of height.

When speaking of the differences which exist between the calculated consumption of fuel and water by the plant when tested under full load and that which is observed from the water and coal bills in the month's or year's working, I was at one time doubtful whether any single 24-hour test would include within it the observed losses; but during the past year, having made a large number of such 24-hour tests at our Chelmsford works, I have come to the conclusion that such 24-hour tests which follow a complete cycle of the working are a fairly trustworthy guide to the annual losses; and I cannot too highly recommend the practice of taking such tests, and of showing them graphically in the manner universally adopted by mechanical engineers, and shown by Prof. Kennedy in the discussion which followed on my paper in 1891. Many of you will ask how I have been able to obtain the electrical work at the terminals of the dynamo in the case of the Chelmsford works, where we use alternating dynamos. My answer is, that it is only during the last few months that I have been able to do this; and it is owing to the extreme kindness of Prof. Fleming, and his unwearied attention in perfecting the Mengarini wattmeter for our purpose, that we have been able to obtain a daily record of the electrical energy generated by our alternating plant, as well as that generated by our direct plant. We are able to separate the load in the town shops from the load in private houses owing to the fact that it is the custom at Chelmsford on Wednesday night to close all the shops, so that our load on that night consists entirely of the public lighting, which is an ascertained and invariable quantity, on which is superposed the lighting in the private houses only.

It will be interesting to many here to know that the circumstances under which we work at Chelmsford of supplying the light between certain hours has enabled us to greatly cut down the transformer loss, so that we have been able to show an efficiency of distribution reaching 76 per cent., which I believe is probably as high as has ever been reached with alternating plant; but if we were compelled to keep the supply up through the remainder of the 24 hours, I am afraid that the state of affairs would be widely different. We are also aided by such a large part of our load being public lighting, which goes on throughout the entire hours of darkness in summer and in winter.

FUEL AND WATER.—PART III.

Effects of Distribution Efficiency.

I am obliged to introduce this question into this paper, as there can be no doubt that the high consumption of fuel shown by certain works is partly due to low distribution efficiency; but I do not propose to dwell on this highly important question, which merits a paper to itself, besides being of a highly controversial character. I find that in few cases have the engineers of supply works had the pluck to face this important problem, and to ascertain and state boldly what distribution efficiency they have noted. In several cases, however, this has been done, so that I am able to make the Table VI. reasonably complete. From it you will see that the efficiency of distribution of direct systems, including meter losses, varies between 85 and 91½ per cent., whereas that of converted systems varies between 60 and 82 per cent.; the higher figure being only found where the system of switching transformers in and out of circuit is practised. In the very small loss of from 10 to 12 per cent. observed in the direct systems are included all those due to the accumulators, to the $c^2 r$ losses in the mains, to leakage, and to meters failing to register; and I do not think it is likely in the future we shall be able to improve much, if at all, on this distribution efficiency—in fact, we are assured by our American friends that it would pay us better to somewhat reduce this efficiency by putting less copper in our mains; but we consider that our English practice is right, as in order to get thoroughly steady lighting and good regulation it is necessary to work at this high efficiency, and at the present price of copper it can be easily shown that it pays to do so.

STORES, WATER, LABOUR, AND SUPERINTENDENCE.

Under the head of "stores used in the generating works" are usually included water (which in London and many other towns has to be paid for), oil, grease, waste, packing, gauge glasses, and other materials which are from day to day used in the working of a supply works. The decrease in the stores item in several of the companies has been very noticeable during the last few years of working. In the case of the Kensington Court works of the Kensington Company, the stores have in some months reached as low a figure as 0·025d. per unit sold, and there is no doubt that even a lower figure will be reached as the output and load factor improve. In this question of use of stores the closed type of engine, such as those made by Messrs. Willans, Bumsted & Chandler, and Belliss, of Birmingham, compare most favourably with the open type of engines. During a visit paid to Vienna two years ago, I was told by Mr. Melhuish, the engineer in charge of the Imperial Continental Gas Association, that the consumption of oil by an open-type compound engine which they had recently erected in that station was 16 times as great as the consumption of oil by a Willans engine of equal power; and I think that in many cases differences almost as great as this will be observed between the two types of engines. When it is considered that in the close type the only glands there are to pack are those of the governor gland and at the two ends of the crank shaft, whereas in a compound or triple open-type engine there are certainly not less than eight important glands to pack, and not less than 20 oiling points requiring separate attention, it will be seen how great the difference is. In the case of rope driving sets there are in most cases three dynamo bearings to be oiled instead of the one bearing in the case of the direct driven set, and the side strain on the bearings necessitates nearly a five-fold use of oil.

Table VII. gives the cost of stores in the same works as Table III., from which it will be seen that, whereas some of the works using direct driven plant have already come within a measurable distance of the figure of 0·03 for water and petty stores, those using belt or rope driven sets are a very long way from it.

Items 4 *and* 5, *Wages and Superintendence in Works.*

On Table VII. I also give these two items for all of the works, showing a slow progress towards my ideal figure of 0·2d. per unit. This table shows that the lowest figure yet reached is 0·38d. per unit; but, as this figure is very largely a question of output, it is certain that from the increase of output alone, and without the introduction of any refinements having for their object the reduction

of the staff employed in the stations, the wages and superintendence charge may be easily brought down. It is evident, however, that this charge must be much higher in the case of belt or rope driven machinery than is the case with direct driving, and Table VII. shows this to a very marked extent. There is every reason to believe that with direct driving closed type engines 1,000 kilowatts will demand

TABLE VII.

COMPARISON OF STORES, WAGES, AND SUPERINTENDENCE COSTS.

Works.	Distinguishing letter.	Stores and water.	Labour and superintendence.	Description of plant.
CONVERTED ALTERNATING SYSTEM.				
Newcastle and District	A	0·27	0·83	Steam turbine.
Leeds	B	0·21	1·37	Alternators, rope-driven.
Bournemouth	C	0·27	1·24	" "
House-to-House	D	0·41	1·25	" "
Newcastle-on-Tyne ..	E	0·163	0·72	" "
Metropolitan	F	0·24	0·75	Mixed system.
Eastbourne	G	0·14	1·4	Alternators, rope-driven.
Exeter	H	..	..	" "
Average	..	0·24	1·19	
MIXED SYSTEM.				
City of London	I	0·23	0·91	Mixed system, driving.
Chelmsford	J	0·16	0·94	" "
CONVERTED CONTINUOUS.				
Chelsea	K	0·34	0·77	Dynamos, driven direct.
Oxford	L	0·045	1·24	" rope-driven.
DIRECT SYSTEM.				
Preston	M	0·45	1·35	Dynamos, driven direct by double-acting engines.
Liverpool	N	0·15	0·37	Dynamos, driven direct by single-acting engines.
Birmingham	O	0·17	0·82	" "
Charing Cross & Strand	P	0·185	0·61	" "
Hove	Q	0·2	1·44	" "
St. James's and Pall Mall	R	0·11	0·75	(1892) " "
Bradford	S	0·094	0·81	" "
Brighton	T	0·162	0·96	" "
Kensington	U	0·15	0·61	" "
Westminster	V	0·19	0·95	" "
Knightsbridge	W	0·17	0·60	" "
Average	..	0·15	0·72	
Ideal Works ..	N to Q S to W	0·08	0·2	

the services of only one attendant, whereas it is doubtful whether with rope or belt driven and open engines one man could attend properly to more than 600 kilowatts of plant. This, however, is only my opinion, as in neither case has the output of any existing works been sufficiently large to enable the attendants to have their time occupied in the most profitable manner; it is quite certain, however, that under present conditions the use of accumulator storage has a most important effect on reducing the cost of attendance. Whether this will be so in the future, when the all-night loads begin to be heavy, I am at present not able to say, but I hold a very strong opinion that a proper proportion of accumulator storage will even in large stations reduce the cost of attendance at least 30 per cent., and in smaller stations from 40 to 50 per cent.

MAINTENANCE.

I have considered this part of the subject with considerable care. It is the one point on which existing opinions vary through very wide limits, and, as far as I can judge, opinions incline at present in what I believe to be an unsafe direction; that is to say, too much has been made of the extremely light cost of repairs of existing works during the few years that they have been running, and figures have been founded on this which I am afraid will turn out to be altogether illusory. In all other businesses the upkeep of boilers which require to be periodically fired up and cooled down, and which have to be heavily fired at times of maximum load, is put down at a figure varying from 5 to 10 per cent. on the original cost of the boilers. The upkeep of steam engines when worked at a far easier rate than is usual in electric supply works is usually taken at from 3 to 5 per cent. on their first cost; whereas the published accounts show that nothing like these figures have hitherto been spent on, or put aside for, the maintenance of these parts of the plant. I do not think that any accurate estimates can be formed of the ultimate cost of maintaining electric generating and distributing plant, other than on a percentage basis such as I have introduced in both my previous papers.

I have therefore prepared Table VIII. to show what has been my own experience in this matter. This table gives the actual sum spent on the maintenance of various parts of the plant of the works of the Kensington and Knightsbridge Company during the last four years out of the seven years that this company has been supplying electrical energy. I have given in the table the original cost of each part of the plant, and have worked out the annual percentage cost which the maintenance bears to the original cost. As some of the steam engines and boilers of this company have been at work seven years, and the bulk of the plant has been at work five years, sufficient time has elapsed for the maintenance cost to have settled down to the figure at which it is likely permanently to remain. As might be expected, the upkeep of the boilers and the accumulators has been more costly than that of any other portion of the plant, but in neither case is the amount as high as I expected it would be. The noticeable feature is the very small sum spent on the upkeep of the engines, of the dynamos, and of the mains.

TABLE VIII.—COST OF MAINTENANCE OF WORKS FOR A PERIOD OF FOUR YEARS, 1890, 1891, 1892, 1893.

Description of plant.	Original cost.	Spent on maintenance in four years.	Per cent. per annum on cost.
	£	£	Per cent.
Buildings	16,593	429	0·65
Boilers	8,124	1,704	5·23
Engines	9,900	704	1·77
Dynamos	8,660	264	0·76
Other plant	12,868	968	1·9
Accumulators	15,115	1,968	3·25
Mains and services	65,167	952	0·36
Meters	6,549	628	2·5
Total	£142,981	£7,616	1·35

The cost of upkeep of the engines is confined to the substitution of small parts as they wear, by new parts supplied from store. It will be seen that the upkeep of the dynamos is almost *nil*; but I must direct particular attention to the small sum spent on the inspection and maintenance of the mains, as this vindicates my often-repeated assertions that a well designed and conducted bare copper system must cost less to inspect and maintain than any system of continuously insulated cables. At any rate, the sum expended on mains as shown in this table is an outside sum, as it includes many alteration items which can hardly be considered as fair wear and tear, but rather in the nature of improvements, and thus chargeable to capital.

The maintenance sum spent by this company has been sufficient to keep the plant in absolutely as good order as when it was first put down, and as I have just said, in some cases has enabled improvements to be introduced which have been charged to revenue. This gives me hopes that future experience will not show any marked increase in these percentage rates, but rather the reverse; so that the ideal figure I have proposed of 0·4d. per unit, which on 5,000,000 units will yield the very respectable sum of £8,300 per annum, will be a sufficient sum to maintain the entire plant in perfect working order for ever.

I have now taken you through all the items of cost of an electrical supply works, and have endeavoured, as far as possible, to compare what has been done up to date with an ideal possible standard. Whether this standard be ever reached or no, I think it will serve the useful purpose of holding before you a goal which we may all strive to attain, and that without the necessity for bringing out any wonderful revolutions in our practice, or, in fact, doing anything but intelligently perfect, and use our present appliances.

I hope my efforts in preparing this paper will be appreciated by those to whom it is addressed. I personally have the warmest sympathy with and admiration for the work of the large number of young electrical engineers who are now scattered over the various supply works, and to whose efforts we are indebted for the very marked advance in economy that I have this evening brought before you. I sincerely hope and trust that the means I have adopted of circulating the paper before the meeting will have given time to these works engineers to appreciate some of my points, so that we may have the advantage of having the important questions that I have raised ventilated and discussed by those who are most competent to do it, namely, the resident engineers of electrical supply works.

In conclusion, the art of electrical supply has now passed from the stage of estimate and talk into that of commercial enterprise. What is to be learnt from the tabulated results of commercial enterprise I have endeavoured to bring before you with the main object of showing what are the possibilities of cheapening electrical supply in the immediate future, as I feel strongly that if we electrical engineers are to play our part in making this an electrical age, the electrical supply must be so carried on that the poorest can avail themselves of it as well as their richer neighbours. Once this is done, many of the problems of electrical supply will be simplified. I think most engineers will agree that it is a far easier and more satisfactory matter to supply electricity to small consumers than to large ones, and it is certain that when electrical supply can be extended to small tenements it will have a very powerful influence in increasing the material comfort of the poor. In fact, I may say that until electric supply becomes general, I consider we have only touched the fringe of our task.

I say this because I think it quite possible that some of my critics will divert the discussion into side issues. I hope I have made it clear, however, that it is only a careful study of the wider problems connected with the economical use of fuel, economical use of steam, and economy in maintenance that such future cheapening is to be looked for.

I cannot conclude this paper without expressing my thanks to the very large number of gentlemen who have assisted me in my labours. In order to get together the data necessary for the production of this paper, I have had to visit a number of stations, and write a large number of letters to the engineers of stations which I could not visit. As it may be the wish of many of these gentlemen to preserve their anonymity, I do not thank them by name. As regards stations with which I personally am closely connected, the importance of anonymity is not so great, and I have therefore the pleasure in stating that much of the splendid results that have been obtained from some of my own stations—the figures of which no doubt some of you have recognised in the tables before you this evening—are due to the continued hard

and intelligent work of Mr. Miller, the resident engineer at Kensington, Mr. Barley, the resident engineer at Knightsbridge, and Mr. Pott, the resident engineer at Chelmsford.

In reading his paper Mr. Crompton made several additions. On page 500 of ELECTRICAL REVIEW, after the second paragraph, which states:—"As regards the evaporative . . . . and not a necessity," read, "Since this was written, we have been almost continually making experiments, and we find it is undoubtedly true that by exercising very great care and watchfulness you can get as high an efficiency out of a Lancashire boiler as out of any other; but it must not be fired heavily. The great care means that you have to pay higher wages to the stokers, and any mistake on the part of the stokers affects the efficiency of this boiler, which might not be the case with a multitubular boiler. That is the real use of the economisers—they cover the errors and mistakes of the stokers."

On page 500, right hand column, after the paragraph "Referring to Table III. . . . . after on the part of the stoker," read as follows:—"Since writing this I have made repeated trials, with the result that on test trials the 5·2 evaporation can be brought up to 8 lbs, and can be maintained so long as the test apparatus is in position and you can advise the stokers what to do; but as soon as it is removed it falls down again. There should be some means of continuously knowing what the composition of the escaping gases really is, for without some knowledge of this some very large errors are easily made. Unless you have some heat-trap in the shape of an economiser you are certain to do badly in the long run."

DISCUSSION.

Prof. PERRY asked Mr. Crompton if he would supplement the information in the paper, by telling them whether the Lancashire boilers, so frightfully condemned, burnt more than 20 lbs. of coal per hour. Were they forced? Were they in towns, for example, where space was valuable, or was there a chance for the Lancashire boiler being efficient?

A MEMBER asked whether in the amount stated in Table VIII. for cost of renewals and maintenance any account had been taken of machinery and other things sold? Had the price obtained for sets sold been deducted from cost price, and the difference put down as cost of maintenance?

Mr. CROMPTON said, in respect of the Kensington station, there had been a very small amount sold, but he did not know whether it had been deducted or not. He was inclined to think it had been; but it did not affect the matter at all. As to forcing Lancashire boilers, the whole pith of the matter lay there. He thought much of the bad effect arose from their being attempted to be forced, but he had no certain information upon the point.

Mr. RAWORTH then opened the discussion. He said he imagined this was the most comprehensive paper upon the question of works' cost and management that had ever been laid before the Institution. He had read the paper carefully through, but had very far from digested it. In fact it seemed to him to include very nearly the whole education of an electrical engineer, and it would be a very long time before they would all of them put it into actual practice in the way of attaining the ideal that Mr. Crompton had obligingly and magnanimously laid before them. He found in the paper only two lines which were absolutely superfluous; those were the lines in which Mr. Crompton expressed the hope that his efforts to put those figures and recommendations before them would be appreciated by that Institution. On what occasion did Mr. Crompton ever speak to that Institution without being fully appreciated? Mr. Crompton always got their attention, first of all because he was one of their most eminent engineers, and, secondly, because he was such a magnificent sportsman. Mr. Crompton was never satisfied with reading a paper and saying to himself "Now, this is a paper that everybody will agree with," but he spotted it all over with beautiful little pin points, and said to himself, "Now, this will fetch them if anything will." He put a little bit of a curl at the end of a diagram, and said "That will fetch Kapp, or if it does not fetch him it will fetch Dr. Thompson," and then he would squirl in a little about alternate currents, and said "That will fetch Mordey, or if not it will fetch Raworth. He (Mr. Raworth) had begun first, as it happened, but he had no doubt the others would follow fast enough afterwards. There were several points in which he (the speaker) took very great interest. Mr. Crompton had never spoken to the Institution on a question of engines and boilers without his either disagreeing with him or giving him some advice, and it was very pleasant to him to be able to notice that he had taken some of the advice he had given him on a former occasion to throw up Lancashire boilers and pin his faith to Babcock boilers. Without going into detail, he would like to look at some of the broad points of the paper which were really the most interesting. Mr. Crompton was endeavouring to show the possibility of reducing the cost of electricity to 3d. per unit to the consumer, and he arrived at the figures he had given them by first of all reducing the capital, and secondly, by increasing the output, and thirdly, by using better engines, boilers, and dynamos. At first he thought the figures of 2s. of capital expenditure per unit of annual output was scarcely justified; but on looking over the matter he found Mr. Crompton was perfectly justified in putting those figures before them, for at Bradford and Newcastle they already delivered 8 units per sovereign of capital expenditure; the next best were the St. James's, 6 units, and St. Pancras, 5 units, per sovereign. Then came Bournemouth, Westminster, and Charing Cross, who delivered 4½, the Metropolitan, Kensington, and Liverpool gave 4; and last of all came Preston and Oxford with 2. Of course it was too bad to try to apply the moral in these cases, because stations were so remarkably various. But at Oxford, which he believed was put forward as a perfect system, the cost appeared to be rather too much for it to be likely to pay a dividend to its shareholders. There was one very important point Mr. Crompton had made in connection with coal. It might be remembered that some year or two back, Mr. Crompton put forward a table in which he corrected all the prices per unit for coal expenditure by putting them through the sieve of their British thermal units, and bringing them all up to one level, and showing what the cost per unit of coal would be in each station if the value were duly corrected. He (Mr. Raworth) then pointed out that hydrogen, which, although it counted perfectly well in the table, did not count in the boiler. He saw now that Mr. Crompton had fallen in entirely with his view and had corrected his own views on that point also. With regard to the boiler question, it was only of late years that they had had the advantage of having accurate tests carried out by Prof. Kennedy, and one or two others, upon whom everybody placed the greatest reliance; but his (the speaker's) connection with the Babcock boiler went very much further back than that. He first saw one in a shop window, behind plate-glass, in 1880 or 1881, and when he saw it he said, "That's the boiler for my money," and he had never bought any other since except under compulsion. He would say for everybody's benefit, that those boilers had given him most perfect satisfaction. He thought that since that date he had probably put down considerably more than half the Babcok boilers sold in this country, and except in one case, where from some extraordinary cause three tubes were burnt out, he had never had any serious trouble whatever. He quite agreed with Mr. Crompton, although it was quite contrary to what every boiler maker would tell them, that Babcock-Wilcox boilers did not give wet steam. That was constantly put before them, and, of course, in the eyes of those who had to work electric lighting plants it was a very bad fault indeed. Now, he would go to the question of engine efficiency, upon which Mr. Crompton put such great stress, and he quite agreed that it was a matter of the very first importance that the I.H.P. they got in their engines should be transmitted to the dynamo and given out in units. Mr. Crompton was one of the first to put the theory of direct coupling into practice, and they owed him very great credit for the example he had shown in that direction. He could assure Mr. Crompton that they who had to build alternating current plants would have followed his example long since if it had been possible, but in the early days of the alternating current industry they could not get the money to do it, and in the second place they did not see their way to do it, because, as they all knew, they could not run an alternator at any speed they liked; they had to run it at a speed which was in accordance with the periodicity of the system they had chosen. Therefore they had to find some other means of driving, and they took to rope-driving, which had been pretty generally adopted, but they had found out—in fact they knew all the time—that the sooner they could get rid of the ropes the better, because they were losing something like 6 per cent. all the time they were running—not 6 per cent. of the load only, but 6 per cent. solid loss. Therefore as soon as they could see their way to do it they would abandon rope-driving and come on to direct-driving also, so if Mr. Crompton would at some future time give them further statistics he hoped the alternating current plant figures would come out very much better than they had done now. Coming to engine losses, Mr. Crompton was a great admirer of the Willans engine, and rightly so, for it had stood the industry in very good stead, and he himself admired it very much indeed. But when Mr. Crompton said the Willans engine was more efficient from the point of view of mechanics he was under a wrong impression. He knew very well that the efficiency obtained was 89½ or 90, which was very good, but it was owing to the fact that makers of ordinary double-acting vertical engines never had the apparatus for testing their engines that the idea arose that this efficiency claimed for the Willans & Robinson engine was the top one. He could get—and anybody could get—from the ordinary vertical double-acting engine 92 per cent.; it could easily be got—there was no trouble whatever about it, no special arrangements, simply take the engine, put the steam on, take the readings, measure the power, and you had it right off. Of course if the crank-shaft were a great deal too large and the piston rings a great deal too tight they might not get it, but if they followed the ordinary rule of putting the bearings close together and doing away with the necessity of having the crank-shaft too large, and did not make the piston rings too tight, they would get it right off without the slightest trouble in the world. The reason the idea had grown up that the Willans engine was so much more efficient than ordinary engines was that the ordinary engines which had gone through many and accurate tests had usually been horizontal engines, and in those cases they had to drag pistons weighing tons backwards and forwards at the rate of 500 or 600 feet a minute without any wheels on them, on the bottom of the cylinder, and that made it almost impossible to get a high efficiency, and made the Willans engine so much ahead of ordinary engines. But he would point out that the Willans & Robinson engine was extremely efficient on the down stroke only; on the up stroke it lost its efficiency, because when going back it was doing no work. Therefore, if they could make it double-acting probably its efficiency would go up to 95 per cent. He thought Mr. Crompton had fallen into one pretty serious error in regard to the efficiency of distribution where it referred to alternating current systems. In central stations the engineers simply took ampères multiplied by volts for their outgoings. As a matter of fact it was much less than that. The alternating current systems were used in districts which were not to be compared with the districts where continuous currents were used. Taking Bournemouth as an instance, there were miles upon miles of wires in all directions; in fact they could scarcely see from one consumer's house to another. Compare this with St. James's, where the work was not much different from lighting up a large hotel. Therefore without large local knowledge it was almost impossible to form an accurate conclusion. But Mr. Crompton had done a thing which nobody else had done. They had a good many professors, mathematicians and paper readers in the Institution, but they had only one prophet, only one who would run the risk of exposing himself to the objection of his prophecies not

being carried out. He knew when he made them that he ran that risk, and although many of them were borne out, to his credit, yet occasionally some of them did not turn out right, and he had to bear the brunt of it; therefore, they ought to give him the very highest honour the Institution could afford.

The discussion was then adjourned until Thursday, May 10th.

Physical Society, April 27th, 1894.

Prof. A. W. Rucker, F.R.S., President, in the chair.

A paper on The Mechanism of Electrical Conduction: Part I, Conduction of Metals, was read by C. V. Burton, D.Sc.

Considering a body not at absolute zero of temperature, the author shows that electro-magnetic radiation would result in heat being degraded into a lower form of energy, if any parts of finite electric conductivity were present, and from the fact that our planet is not devoid of heat, deduces the following theorem I.:—"In a region containing matter, there may be (and probably always are) some parts which are perfect insulators and some parts which are perfect conductors, but there can be no parts whose conductivity is finite, unless every finitely conductive portion is enclosed by a perfectly conductive envelope." This conclusion is in accordance with Poisson's theory of dielectrics and with Ampère's and Weber's theories of magnestism and diamagetism respectively. Theorem II. is enunciated as follows:—"In metals, and in other non-electrolytes whose conductivity is finite, the transmission of currents must be effected by the intermittent contact of perfectly conductive particles;" and as a corollary Theorem III. is given:—"If we suppose that in a substance at the absolute zero of temperature there is no relative motion amongst the molecules or amongst their appreciable parts, it follows that every substance at this temperature must have either infinite specific resistance (which does not imply infinite dielectric strength) or infinite conductivity. Fleming and Dewar's experiments on pure metals tend to confirm this. The author then shows why, on the intermittent contact hypothesis, a conductor is heated when a current flows through it. On the assumption that in ordinary conductors the relation between the electromotive intensity in the inter-molecular spaces and electric displacement, is a linear one, and that the electric forces are small in comparison with the ordinary inter-molecular forces, Ohm's law is deduced. A model is next described by means of which contact E.M.F. and the Peltier effect can be represented and explained. And in considering volta E.M.Fs., the author points out that it is doubtful whether experiments in a perfect vacuum could decide the questions at issue in the contact-force controversy. The fact that the transparency of metals is much greater than Maxwell's theory indicates, might be explained without attributing any new properties to the electro-magnetic field by supposing the dimensions of molecules not quite negligible in comparison with the wave length of light.

Prof. S. P. Thompson thought the paper had an important bearing on the kinetic theory of solids. He saw no reason why Ohm's law should be proved, for he regarded it as a definition.

The President said the author represented all actions as being due to collisions, thereby introducing the same difficulties as were felt in the kinetic theory of gases, viz., that collisions would give rise to mechanical oscillations in the molecules of shriller and shriller pitch. Prof J. J. Thomson had recently given an explanation of electrical phenomena by vortex filaments.

After some remarks on the visibility of molecules by Mr. Hovenden, Dr. Burton, in reply to Prof. Thompson, said Ohm's law when expressed as $\frac{E}{C} = a\ constant$, was really a law and not a mere definition.

A communication On the Design and Winding Alternate Current Electro-magnets, by Silvanus P. Thompson, D.Sc., F.R.S, and Miles Walker, was read by the former.

The paper describes experiments, showing that when the magnetic induction does not exceed 4,000 (C.G.S.), the pull exerted by a laminated electro-magnet on its armature is the same, whether it be excited by a continuous or by an alternating current of equal strength. For higher inductions the continuous current gives slightly greater force. Another experiment made with solenoids and the U-shaped plunger of a Brush alternate current arc lamp gave similar results.

In considering the question of winding alternate current electro-magnets so as to obtain a given excitation when the current is supplied at constant voltage, it is shown that the ampère turns are inversely proportional to the number of turns, for the impedance varies nearly as the square of the number of turns. One important property of such electro-magnets when supplied at constant voltage is that they give a fairly constant pull over a long range, for as the armature moves away from the magnet the current increases, thus counteracting, to some extent, the effect of distance. On the other hand the alternating voltage required to obtain a given force is much greater than that needed with continuous currents. With the armature in contact with the core the ratio of the two voltages was found to be 170, whilst separating them by 9·2 mm. reduced the ratio to 21·5.

Prof. Perry pointed out that the constant pull of the alternate current magnet followed immediately from the fundamental equation $e = re + n\dot{\imath}$ when re is small, for if e be constant then $\dot{\imath}$, and therefore $\imath$ and $\imath^2$ are constant. He was interested to see that the pulls for equal ampère turns were the same, and indicated how the problem could be worked out mathematically when hysteresis was taken into account.

Mr. Blakesley thought it better to fill the space on a magnet full of copper rather than use wire only just large enough to carry the current, for the loss of energy would be reduced. Some of the formulæ given might be put in simpler form.

Mr. Swinburne said an alternate current magnet would only give constant pull in special cases. As another rule for winding alternate current magnets, he said, wind the magnets as for continuous currents and put a condenser in to take the same current, thereby reducing the voltage required.

Mr. Blakesley said it would require a capacity of 600 microfarads to suit the magnet mentioned in the paper.

Dr. Thompson, in reply, agreed with Mr. Blakesley that the condenser was impracticable in many cases.

Major R. L. Hippisley, R.E., read a paper on A Graphical Method of Constructing the Curves of Current in Electro-magnets and Transformers, and exhibited a machine for drawing these curves.

Taking the ordinary equation for a simple alternate current circuit $e \sin pt - \frac{d\,B}{d\,t} = R\,i$, where B is the total magnetic flux, and i the current, the author writes it in the form $e \sin pt - m_k L \frac{d\,i}{d\,t} = R\,i$, where L is the coefficient of self-induction of the circuit with the iron withdrawn and m_k the tangent of the inclination of the B H curve at the point corresponding to the instant considered. This equation is integrated for a short part of the cycle during which m may be considered constant, giving $i = \frac{e}{R} \cos\theta_k \sin(pt - \theta_k) + A_k\, e^{-\frac{R\,t}{m_k L}}$. Methods of finding the constants in the last equation are then described, and the method of drawing the current curves step by step explained. The machine for performing the process is illustrated in the paper, and the curve for an electro-magnet fed with alternating current shown. The case of a transformer without magnetic leakage is worked out at some length, and the curves of primary and secondary current determined.

Dr. Sumpner said the author had used great care in working out a difficult problem more completely than usual. In cases such as arise in practice the R i term is small, and for this Evershed showed how to determine the current curves of a transformer when the periodic state had been reached some 5 or 6 years ago. He (Dr. Sumpner), had also shown how to graphically determine the current curves for circuits containing iron in 1888. The author's method was, however, of more general application.

Mr. Trotter enquired whether the machine could be used in practical alternate current problems, say, for example, to predetermine the E.M.F. curve of an alternator.

Major Hippisley replied to the points raised.

NEW PATENTS—1894.

7,985. "An improved method, means, or process of producing caustic soda and chlorine gas by the electrolysis of common salt in solution." T. Drake. Dated April 23rd. (*Complete.*)

7,994. "An improved electrolytic trough or cell." E. de Pass. (Communicated by H. Thofehrn, France.) Dated April 23rd.

7,995. "Improvements in fittings for electric lamps." H. Hirst. Dated April 23rd.

8,007. "An automatic switch for telephones and other electrical apparatus." G. L. Anders and W. Kottgen. Dated April 23rd.

8,011. "Improvements in appliances for increasing the duration of the top carbon of electric arc lamps." F. Jehl and F. von Hardtmuth. Dated April 23rd.

8,041. "Improvements in exploding chambers and apparatus for oil, gas, or similar engines, motors, or pumps." S. H. Adams. Dated April 24th.

8,043. "An improved insulating cleat for supporting conducting wires for electrical circuits." H. B. Wyman and A. C. Goodwin. Dated April 24th. (*Complete.*)

8,061. "Improved apparatus and process for electro-chemical decomposition." H. Carmichael. Dated April 24th. (*Complete.*)

8,086. "An electric alarm for pressure gauges." W. H. Bradt. Dated April 24th. (*Complete.*) [Date applied for under Patents, &c., Act, 1883, Section 103, November 22nd, 1893, being date of application in United States.]

8,115. "Improvements in apparatus for the manufacture electrolytically, of tubes and other articles of circular section." F. E. Elmore. Dated April 24th.

8,117. "Improvements relating to the treatment of sewage and town refuse for transforming the same into fuel." J. Posno. Dated April 24th.

8,125. "Improvements in dynamo-electric machines and electric motors." H. N. Prentice. Dated April 24th.

8,149. "Improvements in electrical measuring instruments." H. H. Lake. (Communicated by J. V. Vleck and E. Weston, United States.) Dated April 24th. (*Complete.*)

8,150. "Improvements in variable speed gears applicable for use in the propulsion of tramcars and otherwise." G. G. M. Hardingham. Dated April 24th.

8,188. "Improvements in potentiometers." F. H. Nalder, H. Nalder, C. W. S. Crawley, and A. Soames. Dated April 25th.

8,215. "Automatic current distributor for multiple telegraphic transmission." I. Bielski. Dated April 25th.

8,218. "Improvements in or connected with electric signalling or communicating apparatus." C. S. Jones and H. C. Collier. Dated April 25th

8,224. "Improvements in electric lighting." J. G. W. Aldridge. Dated April 25th.

8,238. "Improvements in electro-medical apparatus." A. B. H. Clerke. Dated April 26th.

8,240. "An improved ceiling rose for suspending electric pendant lamps." F. W. Ball and J. H. Winter. Dated April 26th.

8,264. "Apparatus for producing artifically, effects of lightning in theatrical performances." S. G. Horton. Dated April 26th.

8,273. "An improved form of shade tilt for electric light flexible wire pendants or other similar fittings." E. A. Claremont. Dated April 26th. (*Complete.*)

8,277. "An improved stop valve for hydraulic high-pressure and low pressure accumulators." W. M. Jefferson. Dated April 26th.

8,285. "Improvements in arc lamps, especially in the reduction of mechanism." J. W. Rogers. Dated April 26th.

8,292. Improvements in or relating to the charging of electrical accumulators or secondary batteries automatically." J. E. Liardet. Dated April 26th.

8,307. "Improvements in and connected with arc lamps and the regulation of the feeding of their carbons." J. J. Fyfe. Dated April 26th.

8,315. "Electrically propelled tramway vehicles." W. C. Bersey. Dated April 26th.

8,317. "Improvements in switches for use at central stations of telephone systems." H. H. Lake. (Communicated by the Antwerp Telephone and Electrical Works (Société Anonyme), Belgium.) Dated April 26th.

8,323. "Improved means of and apparatus for driving light running machines, such as sewing machines, phonographs, and watchmakers' lathes." J. A. B. Fraser. Dated April 26th.

8,328. "Improvements in electric condensers." G. Threlfall. (Communicated by R. Threlfall, Australia.) Dated April 26th.

8,343. "An improved globe or shade holder for electric, gas, or other lamps." G. F. Sanders. Dated April 27th.

8,350. "Improvements in electric batteries." H. H. Leigh. (Communicated by Vohwinkel, Austria.) Dated April 27th.

8,376. "Water-gauge with electric alarm for steam boilers, water-towers, and reservoirs." H. Tommes and A. Wellner. Dated April 27th. (*Complete.*)

8,412. "Improved method of and means for controlling electric currents." A. Frazer. Dated April 27th.

8,443. "An improved arrangement of electrical contact surfaces for producing electrical effects in theatres, &c." A. Fairley. Dated April 28th.

8,478. "Improvements in electrically propelled vehicles." E. J. Clubbe and A. W. Southey. Dated April 28th.

8,480. "Improvements in and relating to galvanic batteries." T. H. Rushton. Dated April 28th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1893.

562. "Improvements in electric measuring instruments." W. T. Goolden and S. Evershed. Dated January 10th. The inventors form a shield or shields of soft iron, external to the instrument to be protected, and in a position normal to the lines of magnetic force, which it is desired to intercept, the connection between the parts of the said shields, their section, material and arrangement being designed especially to suit the direction, maximum strength and conditions of the magnetic field to be intercepted or diverted, and the part of the instrument to be protected. 3 claims.

933. "Improvement in electrical arc lamps." W. H. Lauder. Dated January 16th. Consists of a brass frame swung diagonally across the upper carbon rod, with a lever projecting from the lower end of the brass frame at right angles, and fastened to same. On the lever is a weight that jambs the brass frame on the carbon rod at the two points where it touches it. This frame or clutch is pivoted between parallel levers, fastened stiffly apart; these levers in turn are pivoted on two supports on same side of rod as jambing weight; these pivot holes are slotted in lever at this point. The other ends of the levers are pivoted to a solenoid, the coil of which is in lamp circuit, or (to the armature of an electro-magnet). Under the weight rises a screw, capable of raising the weight and undoing the clutch to a more or less extent. To adjust lamp for starting, weight is slightly raised, clutch slightly undone, carbon rod free to descend, and points go together. 4 claims.

1,574. "Improved means for tapping incandescent lamp circuits for supplying currents to motors and electro-medical and other appliances." J. C. Fell. (A communication from abroad by A. F. Vetter, of New York.) Dated January 24th. Relates to a current adapter, which is in the form of a combined lamp-socket and tap, which may be inserted in place of the lamp in an ordinary lamp-socket, or may itself constitute a wall-socket, or be attached in any improved way to a flexible cord or other electrical fixture. The current adapter is furnished with a chamber containing a switch, by means of which the current may be turned on or off the lamp, and controlled as regards the external translating device, and is provided with electrical connections for receiving flexible cords or wires for taking the current from the current-adapter either in parallel with the lamp, or in series with it. 4 claims.

2,199. "An instrument for the measurement of electric currents." W. Thomson (Baron Kelvin). Dated February 1st. Relates to the apparatus described in the number of the Review for February 9th, 1894.

2,241. "A new galvanic battery." C. A. J. H. Schroeder and H. E. R. Schroeder. Dated February 1st. A bolt of slate, porcelain, agate, or other suitable material, is furnished at each end with threads, lubricated with black lead; on one end of the bolt is screwed a nut of the same or either of the above-mentioned materials. The bolt is then reversed in position, and an amalgamated zinc plate, pierced with a hole of the same diameter as the bolt, is placed upon the same; this is followed by a small plate of vulcanite, slate, or other suitable insulating material, also pierced with a hole of the same diameter as that of the zinc plate. This is followed by a carbon plate of the same width, but somewhat shorter than, the zinc plate; this, again, by another amalgamated zinc plate of the same size as the carbon plate; this by an insulating plate, a carbon plate, and a zinc plate, and an insulator, and so on alternately, until the last plate is in position, when a second nut, by which all the plates are firmly pressed together, is screwed on the other end of the bolt. The complete battery cell thus constructed, when put into action, is placed in a jar or other suitable vessel of such shape that the cell fits closely in one direction, while a free space is preferably left at each side in the other. 2 claims.

3,412. "Improved means for transmitting telegraphic signals through submarine and like cables." A. Muirhead and H. A. C. Saunders. Dated February 15th. Claims:—1. The curb key so constructed, that immediately on the movement of one or other of its levers the battery is applied to cable, and at the end of every such stroke or movement the reverse pole of the battery is kept applied to the cable during the period of the return of the lever to its position of rest, substantially as set forth. 2. The automatic key so constructed that upon one or other of its levers leaving its limiting stop the battery circuit is broken, and remains broken till such lever returns to its position of rest, substantially as and for the purpose set forth. 3. The combination, in a system of transmission of signals through submarine and like cables, of the curb keys or an automatic transmitter constructed as herein described, with double polarised transmitters, substantially as and for the purpose set forth. 4. In a system of transmission of signals through submarine and like cables, the means, substantially as set forth, whereby the currents sent into the cable are caused to flow from the instant the contact levers of the transmitter leave their respective limiting stops, such currents continuing till the levers return to their position of rest.

3,734. "Improvements in secondary battery plates or elements." A. Hough and O. March. Dated February 20th. Claims:—1. The construction of lead peroxide plates for secondary batteries by filling the support with the lead oxide or oxides in the form of a dry powder and setting and forming the same as described, such support being constructed of lead or lead alloy in such a manner that it is capable of yielding, without injury or distortion, to the expansion which takes place during the process of formation. 2. A support of lead or lead alloy capable of yielding, without injury or distortion, to the expansion of the active material during formation, constructed substantially as described.

3,743. "Improvements in the preparation of carbon electrodes for electrolytic operations." E. H. Liveing. Dated February 20th. The inventor submits the carbon to a high temperature in a current or atmosphere of chlorine gas, which treatment will have the effect of removing the impurities to a considerable extent, thereby rendering the carbon, when used as electrodes, more durable, and otherwise more suitable than carbon not so treated, for electrolytic purposes. 1 claim.

3,744. "Improvements in the construction of carbon electrodes." E. H. Liveing. Dated February 20th. The inventor employs as the anode (or positive electrode) broken pieces of gas retort carbon resting on a sieve, grid, or series of bars of slate, porcelain, glass, or other non-conducting material, just as coal rests on the bars of a furnace. He makes electrical communication with this heap of carbon by means of carbon rods, such as arc light carbons, or of protected metallic conductors passing through stuffing boxes in the cover or top of the anode cell, and pressed down and making contact with the heap of carbon on the grid, and as the carbon rods will also waste at their ends, they are made to slide down through the stuffing boxes by aid of a spring or weights.

3,833. "Improvements in electric connections." E. W. Lloyd. Dated February 21st. A screw plug and insulating shield are first placed on to the cable, and part of the protection at the end of the cable is cut away, the wire projecting from the cable may then be threaded through a hole in the stem of the contact piece, divided into two parts, each part slightly twisted and coiled around the stem of the contact piece in rear of the collar, the insulating shield may then be drawn on to the contact piece, care being taken before placing the connection into the case that no wire is projecting up between the shield and the collar when the connection has been placed into the case; the plug may be screwed up hard against the rear end of the shield, pressing the wire against the back of the collar and the front face of the contact-piece against the end of the conductor in the casing. 3 claims.

4,077. "Improvements in the construction of electrical measuring instruments." H. C. L. Holden. Dated February 24th. Relates to a clamping arrangement which is pivoted and turns about the same axis as the coil itself, and which furthermore is so arranged that, when the instrument is in use for measuring purposes, it can be turned on its pivots and thereby placed in such a position as not to interfere in any way with the movement of the coil.